

MARS14 Shielding Calculations for the J-PARC 3 GeV RCS

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MARS14 コードを用いた J-PARC 3GeV RCS の遮蔽計算

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概要

J-PARC 3 GeV RCS のコリメーション計算と遮蔽計算を目的とした MARS14 モンテカルロコードによる放射線輸送シミュレーションを行った。ビームラインのコリメータ領域における線源項として、STRUCT モンテカルロコードによるビームトラッキング計算結果により得られたビームラインの 400 MeV 陽子ビームロス分布を用い、また、400 MeV 入射および 3GeV 出射における局所ビームロスを線源項として与えた。計算においては、「MAD-MARS ビームラインビルダー」を用いて、ビームラインに並ぶマグネット等の機器の配置や曲がったビームラインやトンネル等が従来に比べ比較的容易に体系を作成した。また、「3 次元多重層つなぎ計算」を行うことにより統計精度の良い深層透過計算を行った。

このモンテカルロ計算により、ビームライントンネルの遮蔽コンクリートおよびその周りの土における加速器運転中の線量率分布を評価し、J-PARC における地下水の放射化や一般区域での放射線安全基準に基づきビームライントンネルの遮蔽厚の最適化を行った。運転停止後の維持管理を行う作業者の外部被曝評価のために、ビームライン周りの機器やトンネル壁に対して残留放射能による線量率を評価した。

本報告書は、2001 年に 3GeV RCS のビームライントンネル遮蔽設計を行った際の計算をまとめたものである。計算体系や計算手法に関して詳しく述べ、またモンテカルロ計算に用いたユーザーサブルーチンやインプットカードを掲載した。また、ビームライン機器、局所遮蔽やビームライントンネル遮蔽の内側における運転中線量率、残留線量率および吸収線量率を数値データでまとめた。さらに運転中線量率については、コンクリート遮蔽壁内および地上までの土に関する数値データでまとめた。

本報告書で示したサブルーチンやインプットデータ等は、以下の Web サイトより入手可能である。
<http://research.kek.jp/people/noriaki/MARS>

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Abstract

MARS14 Monte Carlo simulations were performed for collimation and shielding studies of the J-PARC 3 GeV RCS. A 400 MeV proton beam loss distribution, calculated with the STRUCT code, was used as a source term at the collimator region. The localized beam losses of 400 MeV and 3 GeV were located at the injection and extraction, respectively. The beam line module locations in the ring and the curved beam line tunnels were described by the MAD-MARS beam line builder prepared in the MARS code. A deep penetration calculation with good statistics was carried out using a 3-dimensional multi-layer technique. Prompt dose-rate distributions were calculated inside and outside the concrete and soil shield, and an effective shielding design was made based on the J-PARC radiation safety regulation for ground water activation and uncontrolled area. The residual dose rates for various materials and tunnel walls near beam line were also calculated to estimate the external exposures of workers during the beam line maintenance.

Calculation geometries and techniques, and also some of the user subroutines and input data used in this calculation are described. Numerical data of prompt, residual and absorbed dose rates at the beam line modules, local shields, and inner surface of the bulk shield are given here. The prompt dose rates are also given in the deeper regions of the bulk shield and the surrounding soil up to ground level.

Subroutines and input data shown in this report are available at the following web site:
<http://research.kek.jp/people/noriaki/MARS>

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1 INTRODUCTION

A high energy, intense proton accelerator facility (J-PARC, Japan Particle Accelerator Research Complex) projected by KEK and JAERI is now under construction in JAERI site. In the facility with MW beam-power machine, neutron penetration in a shield, activation of materials near beam line due to secondary particles produced by a beam loss are serious problems. Effective shielding designs along the beam line and experimental facilities are therefore required. Besides, estimation of dose rates due to residual activity around the beam line is also important for maintenance after operation. In the previous work [1], Monte Carlo calculation have been performed with using MARS13 code [2] to estimate residual dose and absorbed dose rates of beam line modules for various proton energy beam of 200 MeV~1 GeV. However, radiation transport calculation through very thick shield have been a difficult problem because of inaccuracy due to poor statistics by Monte Carlo calculation.

Although empirical formulae of radiation attenuation and activity production are very useful and convenient tools for rough estimations at the early stage of conceptual shielding design in appropriate conditions, those cannot be applicable for some situations such as distributed source, forward shielding and complicated target structure. Therefore, detail calculations using Monte Carlo simulation for the high beam loss areas are inevitable to accomplish the effective shielding design. However, even using the Monte Carlo method, some difficulties still exist such as poor statistics behind a very thick shield (deep penetration problem), descriptions of many complicated modules in the beam line and the predictions of beam loss distribution.

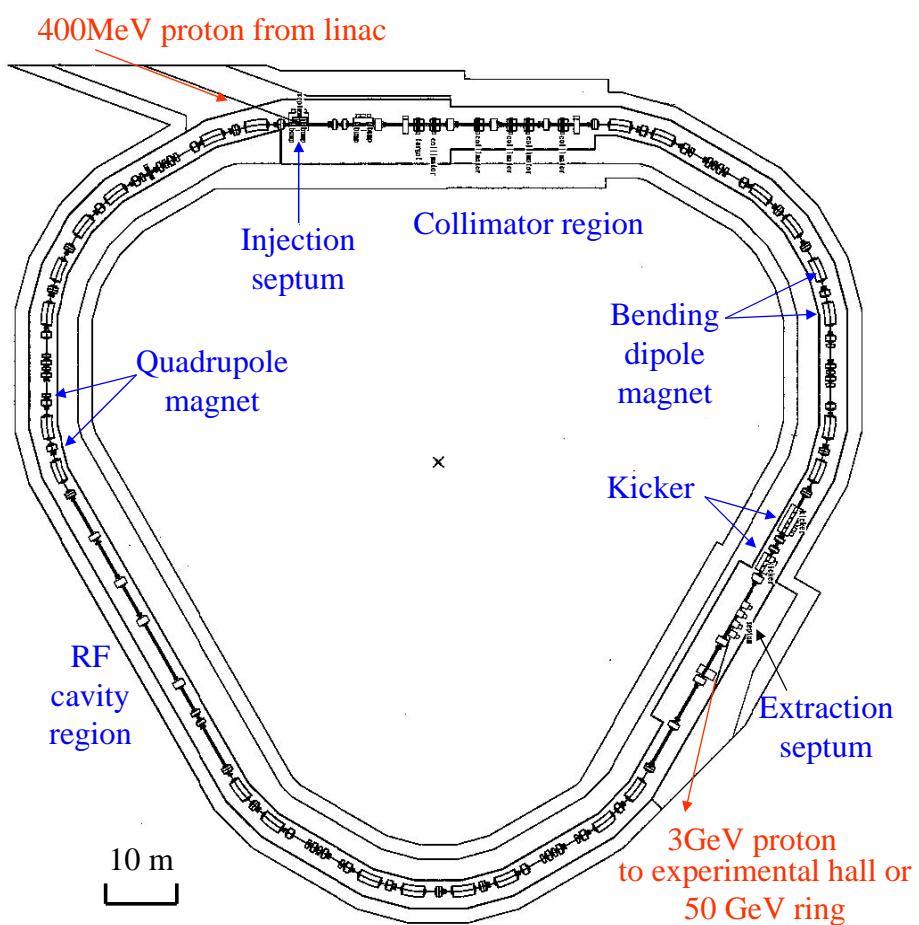
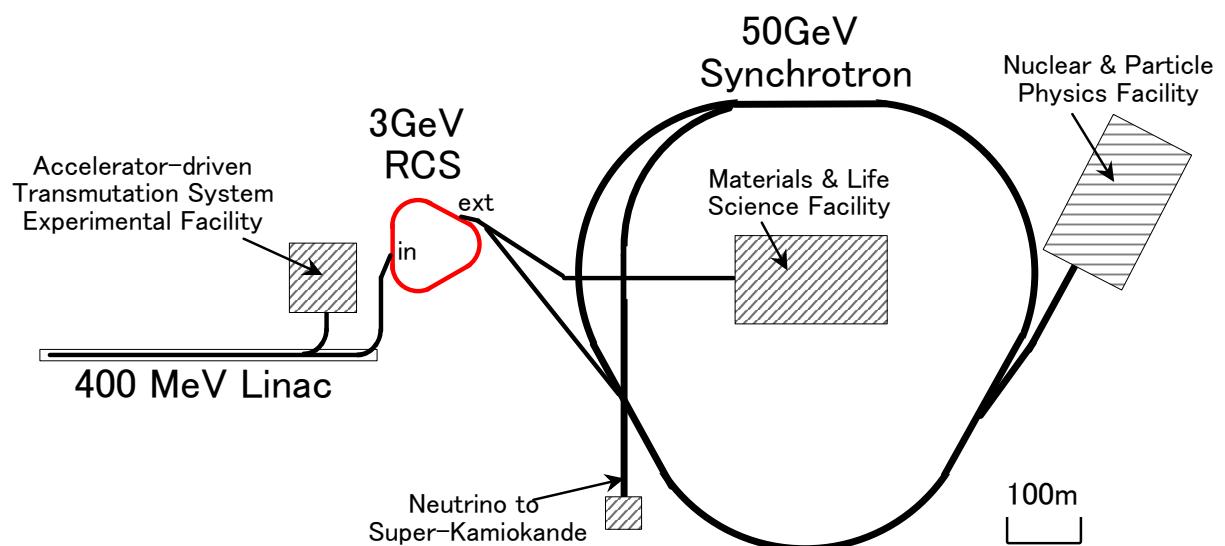
In this work, simulations by the MARS14 Monte Carlo code [2] for collimation and shielding studies of the J-PARC 3-GeV synchrotron ring were performed, and effective designs of the tunnel and local shields were determined based on design standards of the dose rate at J-PARC. In order to accomplish the above difficulties, following three techniques were utilized in this calculation:

- 1) Distributed beam loss was calculated by the STRUCT code [3];
- 2) Beam line modules and bend sections were described by the MAD-MARS beam line builder;
- 3) Deep penetration calculation in good statistics was performed with MARS14 using a 3-dimensional multi layer technique.

Besides, residual surface dose rates and absorbed dose rates at beam line materials and local shields were also calculated in order to estimate external exposures of workers during the maintenance and radiation damages of instruments and beam line materials.

2 J-PARC 3 GeV RCS

Fig. 1 shows the overview of the facility on J-PARC project which consists of a 400-MeV linac, a 3-GeV RCS (Rapid Cycling Synchrotron), a 50-GeV synchrotron ring and some experimental halls. Fig. 2 shows a magnified view of 3-GeV RCS that is the triangle shape with 3 arc regions. 400 MeV protons from the linac are injected into the septum, followed by the collimator region in the first straight section. Kickers and 4 extraction septa are located at the second straight section, and 3 GeV protons are transported to a 50-GeV ring or a material and life science facility for neutron-muon experimental research. RF cavities are located at the third straight section, and 8 dipole magnets are located at each arc. The maximum beam current is scheduled to be 0.333 mA, which is \sim 133 kW at 400 MeV and \sim 1 MW at 3 GeV.



3 BEAM LOSS DISTRIBUTION

3.1 Multi-turn tracking simulation by STRUCT code

Using a multi-turn tracking Monte Carlo code, STRUCT [3], 400 MeV protons of the beam halo were traced along the whole ring, and the beam-loss distribution was estimated [4]. The beam pipe and the collimator aperture and the magnet fields were taken into account in the calculation. 50,000 particles were traced in this work. If the particles go outside the beam pipe boundaries, or lose more than 30% of the primary kinetic energy, the traces are terminated and particle information is stored for the MARS14 calculation. The calculated beam loss distribution along the beam line is shown in Fig. 3 with figures of distributions of a module location and aperture structures.

3.2 Beam loss at injection and extraction

Possible location of the beam loss at the injection area would be at the injection septum magnet, where the incoming and the circulating beams come very close with each other. From view point of shielding design of the synchrotron vault, the loss at the septum magnet was assumed to be 1 kW, which is less than 1% of the total injected beam power. For the extraction, the loss at the first upstream septum magnet (septum-1) was assumed to be 1 kW. The localized beam losses at injection and extraction septa along the beam line are shown in Fig. 3 together with the STRUCT calculation result.

3.3 Beam loss distribution used in the MARS calculation

It can be found in Fig. 3 that almost all of the beam losses occur in the collimator region by the STRUCT calculation with very small amount of beam losses in the other regions. In this work, beam loss beyond 60 m by STRUCT calculation was neglected because in the low beam loss regions, uniform beam loss would be considered and shielding calculation would be carried out using empirical formulae. The loss in the collimator region from 10 to 60 m was normalized to 4 kW, which is 3% of the total injected beam power predicted based on the space-charge calculation with Simpsons code [5].

A magnified view of beam loss distribution from injection through collimator region and that from kicker to extraction region are shown in Fig. 4 and Fig. 5, respectively. Beam losses at collimator, injection and extraction assumed in this work are summarized in Table 1. Proton beam loss configuration is described in Section 4.7 (p.8).

Table 1: Beam losses at collimator, injection and extraction

	E_p [GeV]	Power [kW]	Current [μA]	Particle [proton/sec]
Injection	0.4	1.0	2.5	1.56×10^{13}
Collimator	0.4	4.0	10.0	6.25×10^{13}
Extraction	3.0	1.0	0.333	2.08×10^{13}

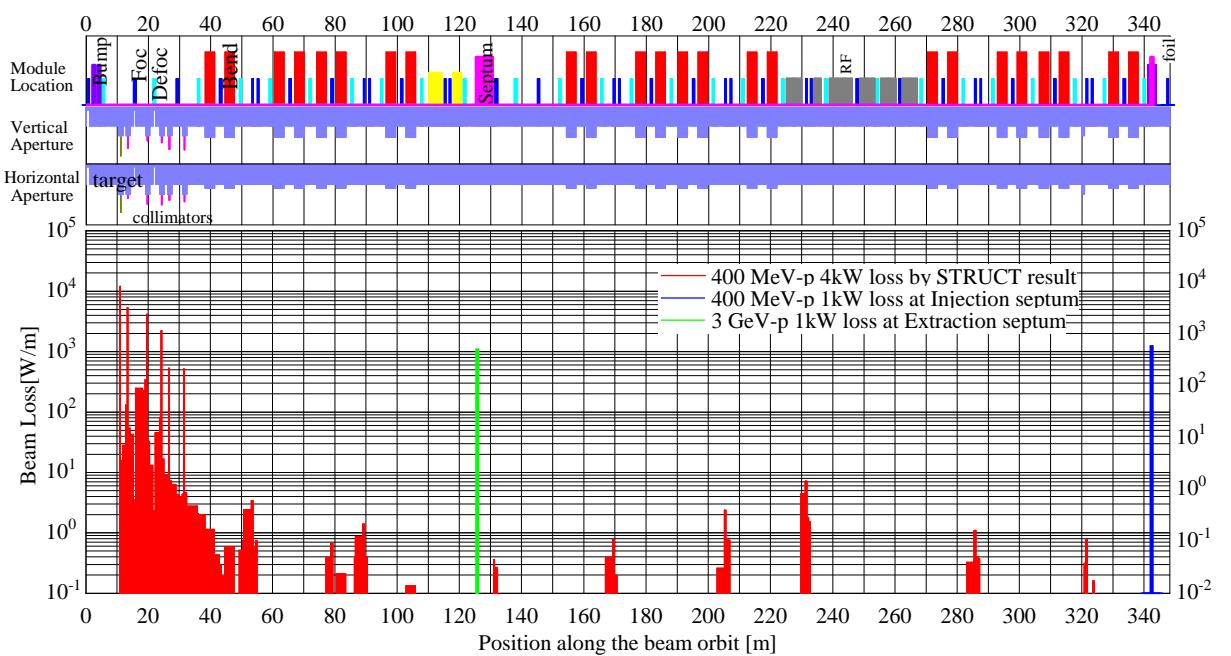


Figure 3: Beam loss distributions along the whole ring obtained by the STRUCT calculation and assumed beam losses placed at the injection and extraction septa.

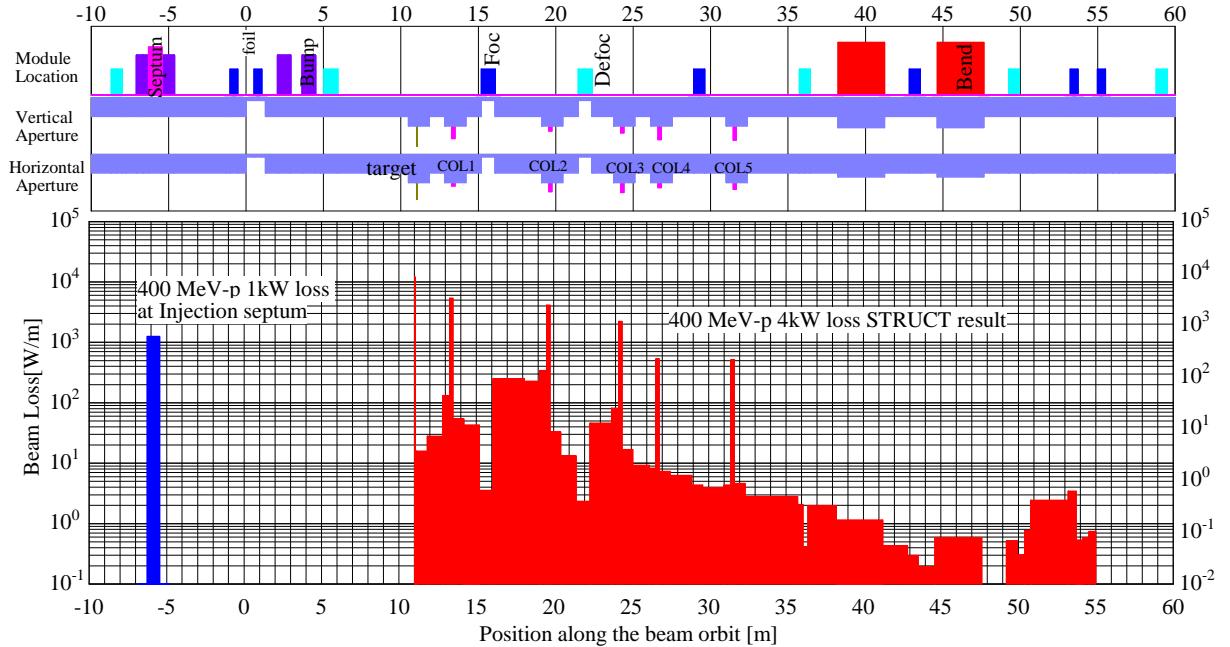


Figure 4: Beam loss distribution in the injection through collimator region.

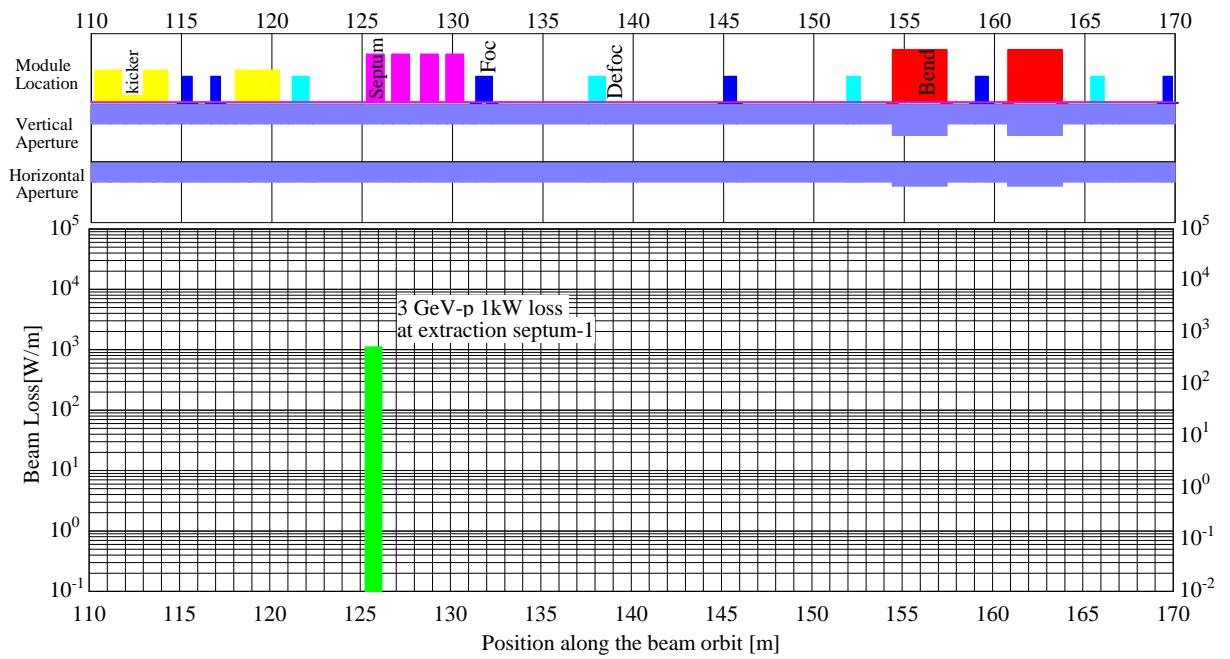


Figure 5: Beam loss distribution in the kicker through extraction region.

4 CALCULATION GEOMETRY

4.1 Tunnel Structure

Fig. 6 shows a horizontal cross section of the whole beam line tunnel of the 3-GeV RCS used as calculation geometry described by the GUI graphic tool in the MARS14 code. The circumference of the ring is 348.333 m and the position of the charge-exchange foil is set to be 0.0 m, as shown in the figure. This ring consists of several regions as injection, collimator, arc-1, kicker, extraction, arc2, RF and arc-3 as shown in the figure. Injection septum at just before the foil and extraction septa at the second straight section are covered with local shields. Five collimators and target are covered with iron and concrete shields and additional local shields are placed at the beam pipe between the collimators.

Fig. 7 and Fig. 8 show vertical and horizontal cross sections of the calculation geometries along the beam axis for the beam line tunnel at the region from injection through collimator and from kicker through extraction, respectively. The beam line is 11.8 m below the ground level and 1.2 m above the main-tunnel floor. A sub-tunnel is arranged below the main tunnel for the electric cables and cooling water pipes. "Inward" in the figures indicate the directions to the center of the 3GeV RCS ring, and "outward" is with opposite direction. Fig. 13 shows horizontal cross section of the calculation geometries along the beam orbit for the beam line tunnel at the region from the end of collimator through arc-1.

The tunnel structure is described by the non-standard geometry written in user subroutines given in Section B.3 (p.93~104).

4.2 Flux Detector Cells in Tunnel Wall

Flux detectors for simulation, which are described as rectangular cells were defined at various positions of the concrete wall and soil region, as shown in Figs. 9~ 12 and 14 to estimate prompt doses for study of shield thickness at four directions(up, down, inward and outward) from the beam line. Residual dose rates and absorbed dose rates at the detector cells were also calculated to estimate activation and radiation damage of the materials near the beam line. Detector cells were placed in parallel to the beam line in various depths of concrete and soil shields. Fig. 15 and Fig. 16 show the vertical cross sections for the beam line tunnel in various locations, which is perpendicular to the beam axis.

Fig. 17 shows a typical cross section of the tunnel indicating the names of the flux detector cells used in the calculation. Positions and sizes for each cell are tabulated in Table 3(p.19). In increasing the shield depth, thickness and width of the cells were set gradually larger to get the good statistics as shown in the figure. Thickness of the cells are from 10 to 20 cm in the concrete tunnel, and 30 to 50 cm in the soil. At soil of the tunnel boundary (US1, DS1, IS1, IS2, OS1 and OS2), thickness of cells were set to be 100 cm to get the average flux in the 1-m soil from the tunnel boundary for ground water activation estimation. Lengths of detector cells for beam direction of tunnel are generally about 100 cm.

Fig. 18 shows coordinates in the vertical cross sections of the beam line tunnel perpendicular to the beam axis which indicate distances ($a\sim q$) from beam line to inner and outer surfaces of concrete shield tunnel. Numerical values are given in Table 4 (p.21). Positions of c , j and q are constant ($c=-120$ cm, $j=-570$ cm and $q=1180$ cm from the beam line) in the whole regions.

The detector cells of machine modules and local shields are mentioned in Section 4.4 and 4.3. Flux and dose estimations are described in Section 8.

4.3 Local Shield

In the high beam loss areas such as the injection and extraction septa and collimators, prompt dose rates at the soil boundary and ground level become locally much higher than in the other area. To avoid the increase of the tunnel wall thickness and minimize the overall amount of the shielding

concrete, additional local shields were proposed around the septa and collimators in the shielding design.

Fig. 19 shows the cross sectional views of a local shield for the injection septum, which is a concrete sandwich structure consisting of inner concrete(conL1), iron(ironL) and outer concrete(conL2). Moreover, the local shield was divided into 4 segments in the beam line direction to obtain prompt, residual and absorbed dose rate distributions. The local shield covers the septum and two bumps, and the 400 MeV-1kW protons were bombarded into the inner coil of the septum. Massive local shields are required, especially for the upward direction, to reduce the prompt dose rate at the ground level.

Fig. 20 shows the horizontal and vertical cross sections of the local shields for collimators and beam pipes, and Fig. 21 shows the vertical cross sections perpendicular to the beam line at the positions of A~E of Fig. 20(a). There are three types of local shields in these figures, collimator shield , local shield-A and local shield-B. Target and five collimators are covered with iron and concrete shields which have four slots in four directions to control the four copper collimators. Additional iron shield is put on the top to reduce the prompt dose rate at the ground level. The other two local shield-A and B were proposed to reduce the secondary hadron shower which spreads in forward direction by the scattering proton beam at the collimators. Locations and lengths of these local shields in the tunnel are shown in Fig. 22.

Fig. 23 shows the cross sectional views of a local shield for 4 extraction septums at the second straight section, which consists of inner concrete (conL1), iron (ironL), outer concrete (conL2) and iron in the top (ironT). Forward shield slab for hadron shower is proposed about 5.8m downstream from the end of the local shield because of the beam line module complexity. The first igloo of the local shield was divided into 4 segments in the beam line direction to obtain dose rate distributions as well as the local shield for injection septum.

Geometries are described by the non-standard geometry written in user subroutines given in Section B.3.3 (p.102) included by the tunnel structure unit.

4.4 Beam Line Modules

The beam line modules, such as the magnet, collimator, target, septum, bump, kicker and beam pipe (drift space), were taken into account as calculation geometries. As seen in Figs. 6~13, various modules are located in the beam line. Geometries are described by the non-standard geometry written in user subroutines given in Section B.4 (p.105).

Figs. 24 and 25 show the horizontal and vertical cross sections of bending dipole magnet, respectively. A beam pipe of elliptic shape is made of 0.5cm-thick ceramic. Several detector cells were defined in the yoke region to estimate dose rates at the inner and outer surfaces, and their names are yoke1, 2, 3 and 4 as seen in the figures. Coils are located at 4 regions.

Figs. 26 and 27 show the horizontal and vertical cross sections of quadrupole magent, respectively. Beam pipe of circular shape is made of 1cm-thick ceramic. Detector cell of "yoke1" is the region of the pole near the beam line, and half sphere shape was defined for it to avoid complexity of the volume calculation for the flux detector cells which are neccesary for estiamtion of flux and dose. "yoke4" is defined at the outer surface of yoke as seen in the figure. Coils are located at 8 regions.

Fig. 28 shows the horizontal cross section of a septum and 2 bumps at the injection along the beam line. Figs. 29 and 30 show the vertical cross sections of the bump and injection septum, respectively. Yoke was divided by several regions to estimate dose rates in detail. Fig. 31 shows the horizontal cross section of 4 septa at the extraction along the beam line. Figs. 32 and 33 show the vertical cross sections of the septum-1 and -4, respectively. Figs. 34 and 35 show the horizontal and vertical cross sections of kicker located just before the extraction along the beam line, respectively.

4.5 Detector Volume

Volumes definition of detector cells needs for estimations of the flux and dose rates. Volumes were defined by giving the formulae in "subroutine ***_vol_func" including each subroutine unit for beam line modules, tunnel and local shield etc.

4.6 Material and Density

MARS build-in materials were used for all materials for shielding and beam line modules. The materials and their densities are tabulated in Table 2. Densities for the shielding materials of concrete, iron and soil were changed as 2.2, 7.7 and 1.5 g/cm³, respectively, based on the J-PARC shielding design standard.

Table 2: Materials and densities used in the MARS14 simulation

	Material	Keyword	Density [g cm ⁻³]
Shielding	Concrete	CONC	2.2
	Iron	FE	7.7
	Soil	SOIL	1.5
Beam line module	Yoke	YODE	7.87
	Coil	COIL	5.11
	Ceramic	CRM	3.97
	Copper	CU	8.96
	Tungsten	W	19.3
	Air	AIR	0.00121
	SUS	STST	8.02
	Aluminum	AL	2.7

4.7 Proton Beam Loss Configuration

The beam loss at the injection was uniformly given at the inner coil surface of septum as seen in the arrows of Fig. 28 and the pointed region of Fig. 30. The beam loss at the extraction was given at the beginning of the inner coil of the septum-1 as seen in the arrows of Fig. 31 and the dotted region of Fig. 32. The beam loss at the collimator region was given at the corresponding coordinate in the beam line with kinetic energy and vector which were defined by the STRUCT calculation results. Detail is described in the Section 3 (p.3).

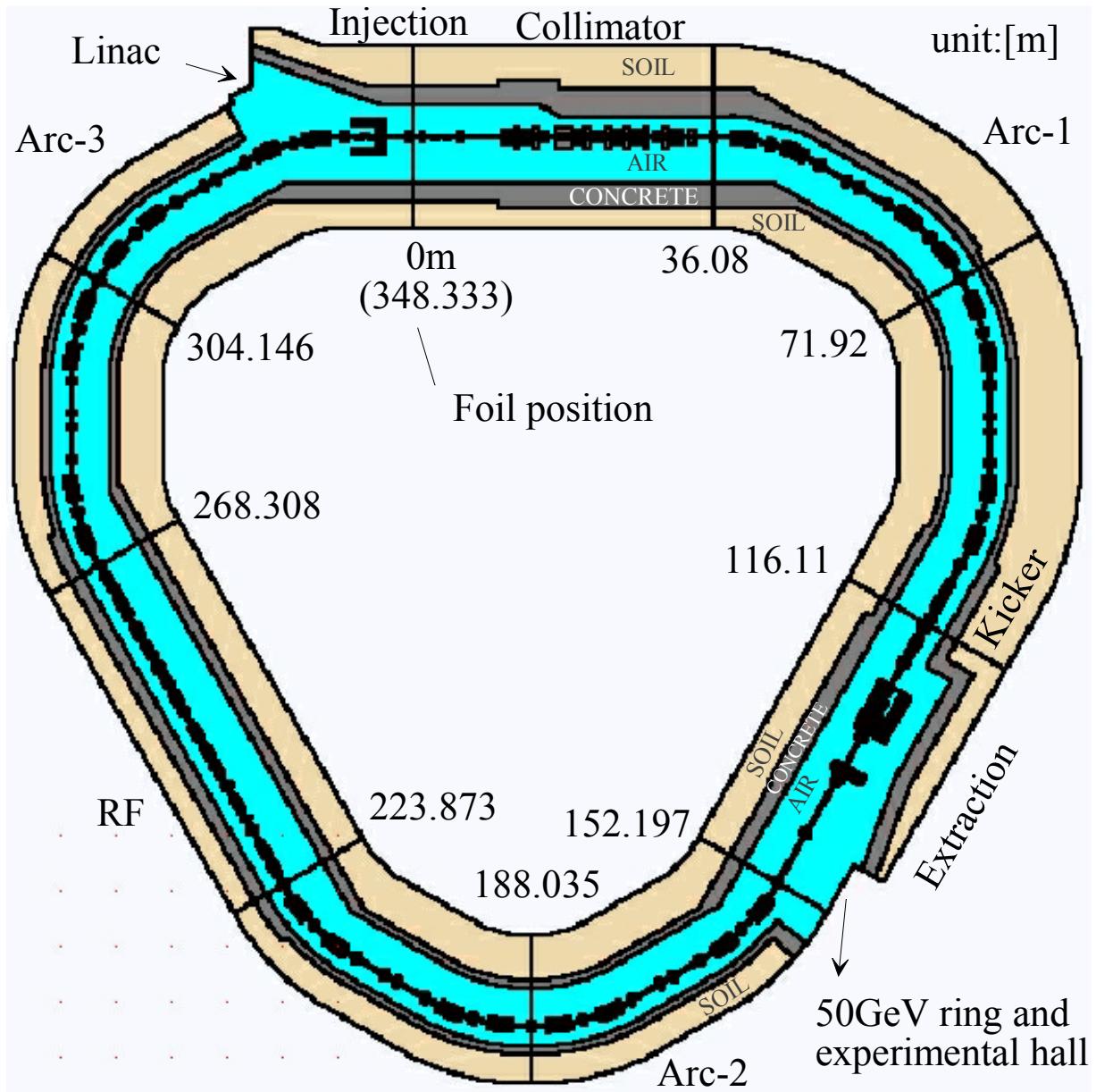


Figure 6: Overview of the MARS14 calculation geometry of whole beam line tunnel for the J-PARC 3 GeV RCS.

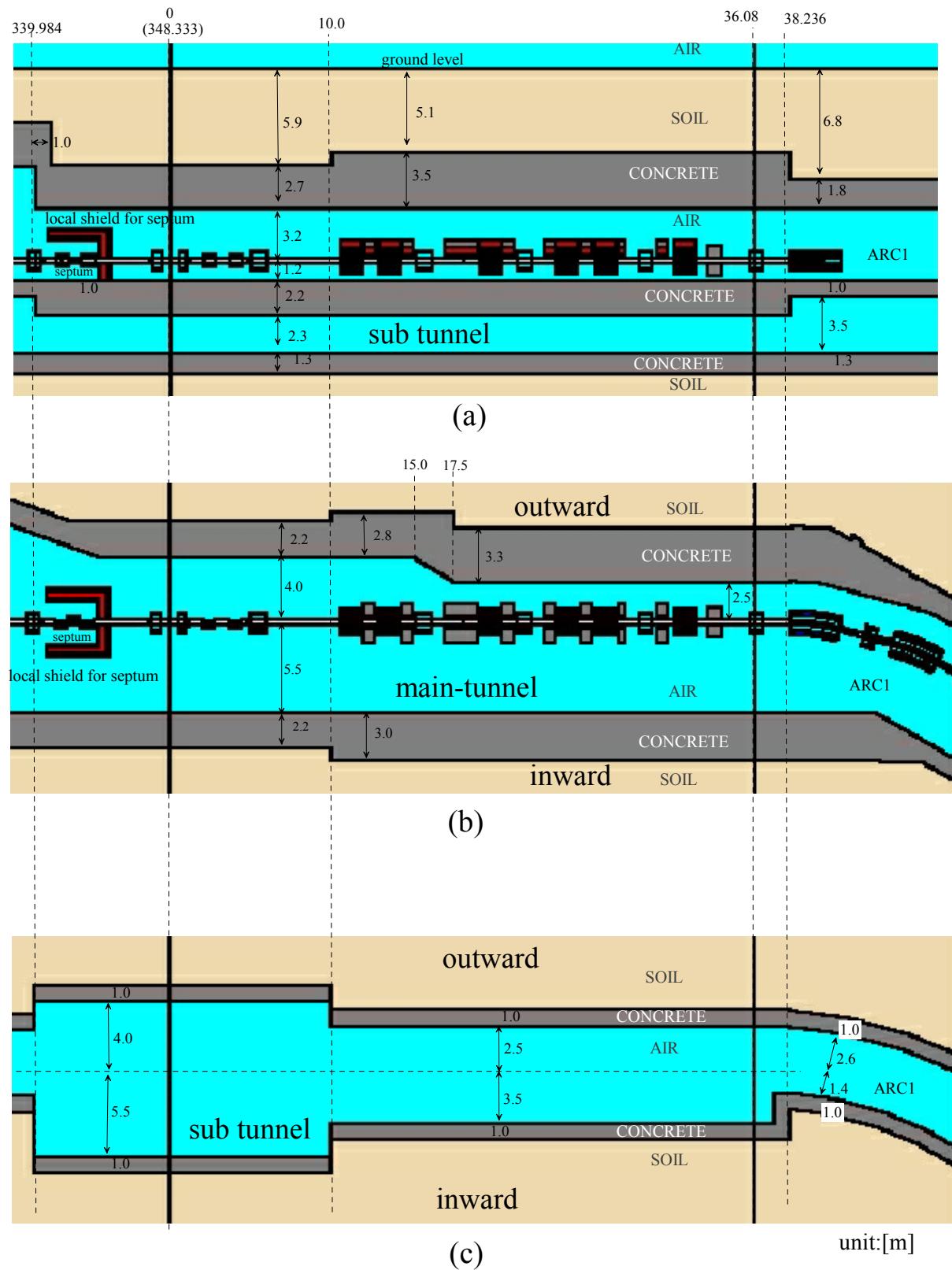


Figure 7: (a) Vertical and (b) horizontal cross sections of the beam line tunnel and (c) horizontal cross section of the sub-tunnel along the beam axis in the region from the injection through the collimator.

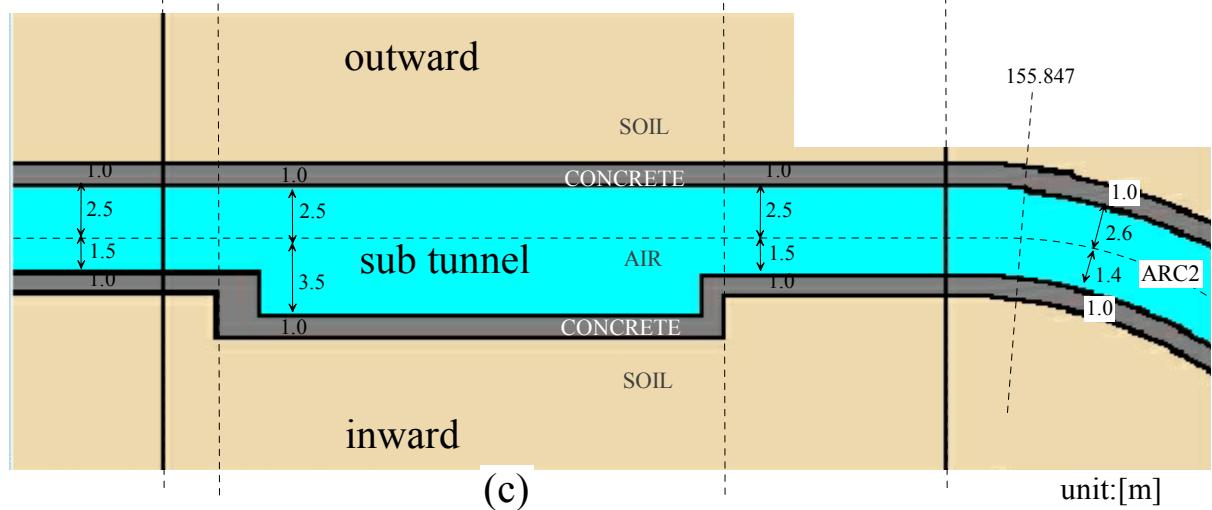
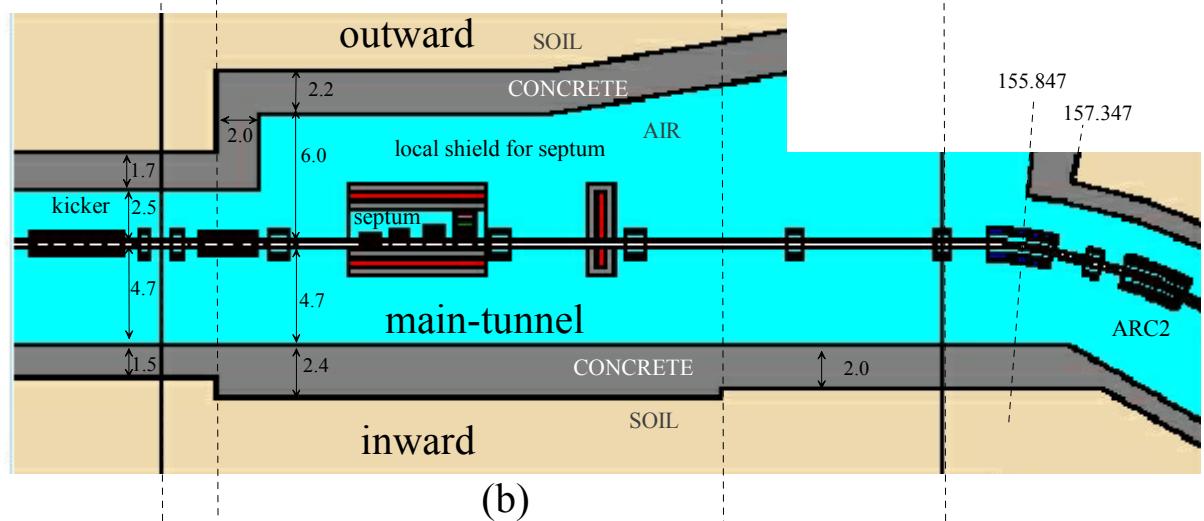
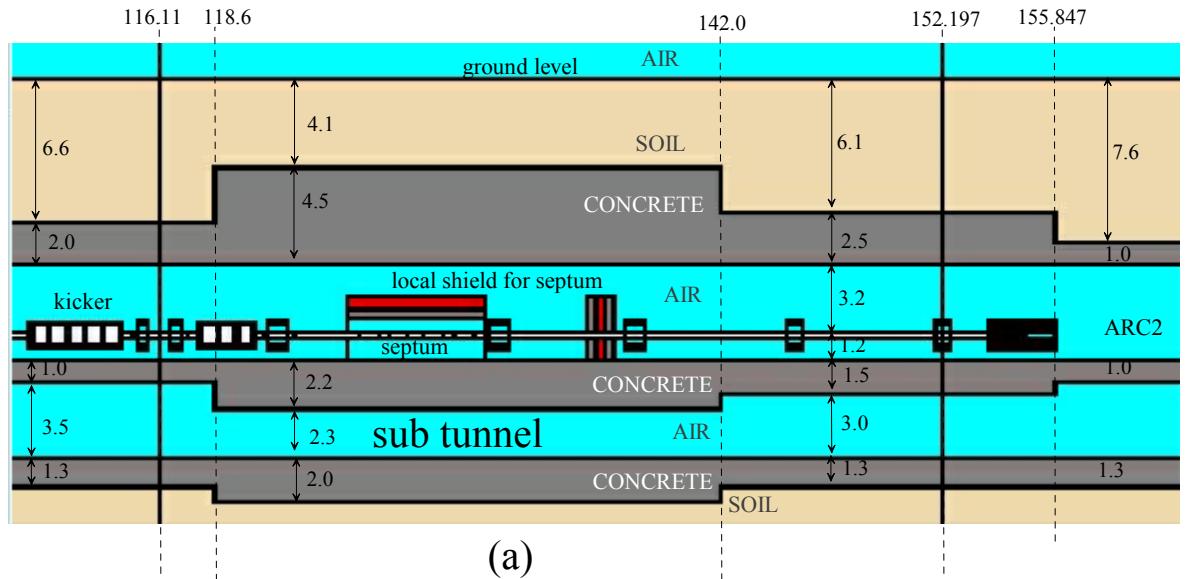


Figure 8: (a) Vertical and (b) horizontal cross sections of the beam line tunnel and (c) horizontal cross section of the sub-tunnel along the beam axis in the region from the kickers through the extraction.

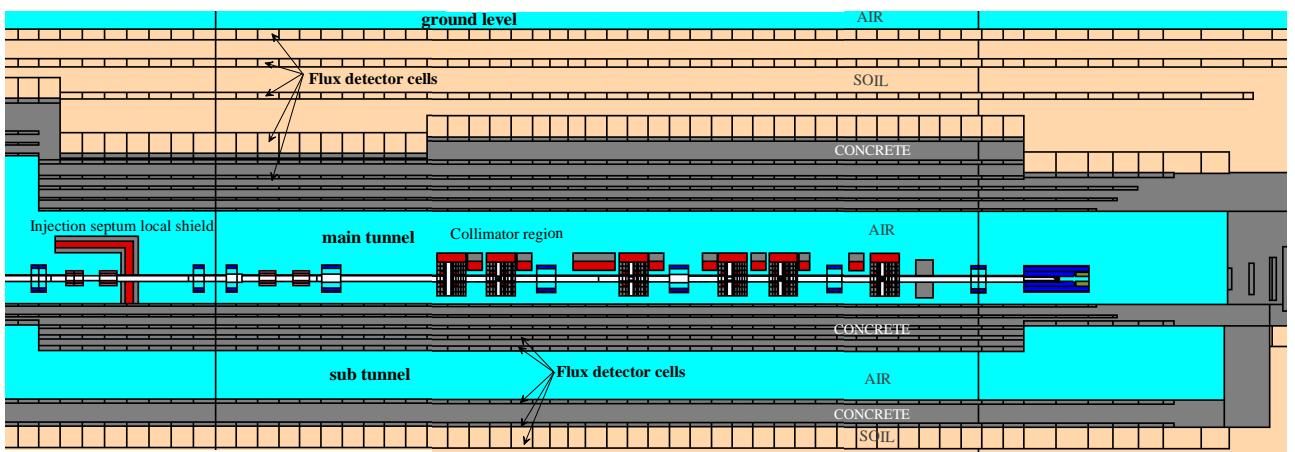


Figure 9: Flux detector cells in the vertical cross section of the beam line tunnel from the injection through collimators.

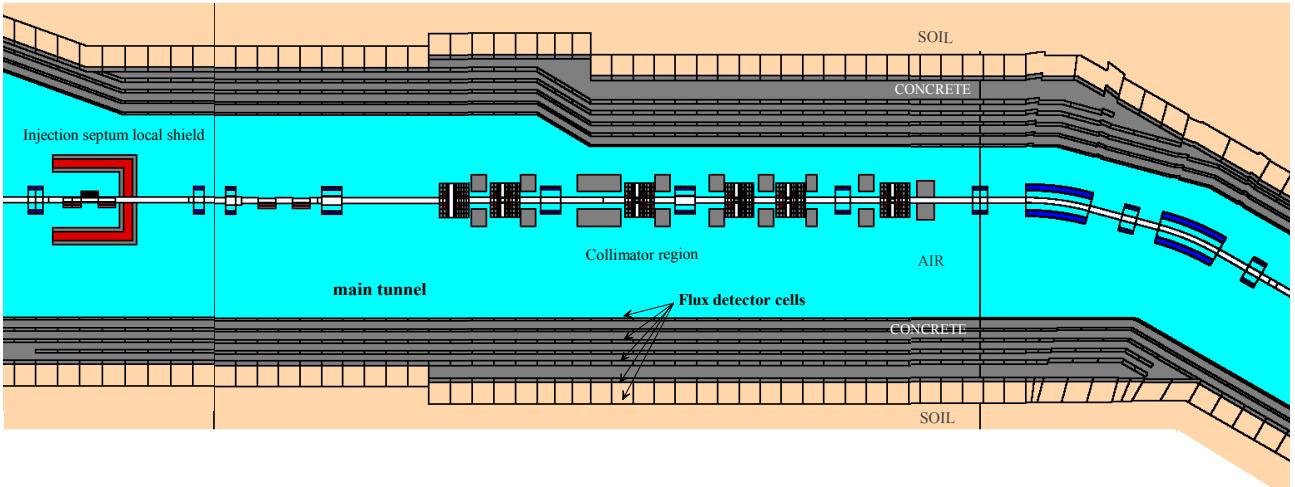


Figure 10: Flux detector cells in the horizontal cross section of the beam line tunnel from the injection through collimators.

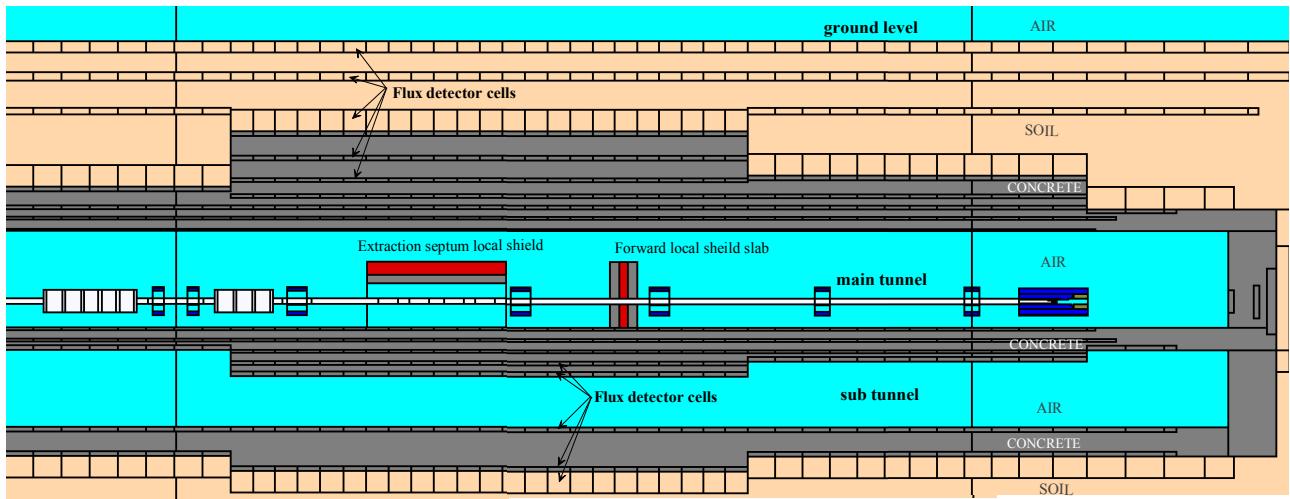


Figure 11: Flux detector cells in the vertical cross section of the beam line tunnel from the kicker through the extraction.

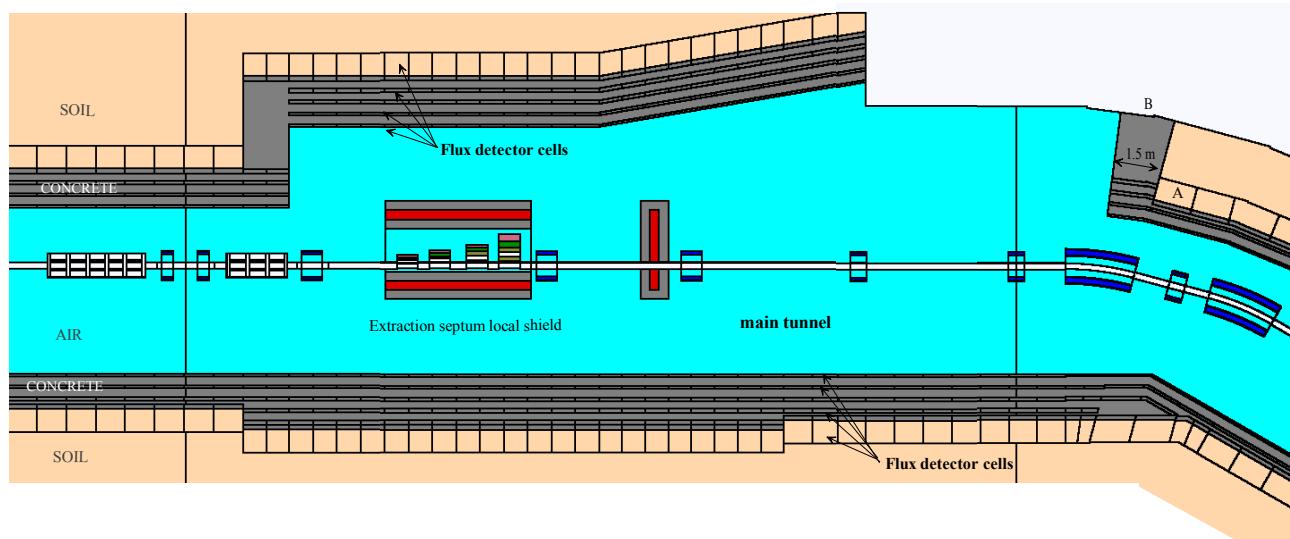


Figure 12: Flux detector cells in the horizontal cross section of the beam line tunnel from the kicker through the extraction.

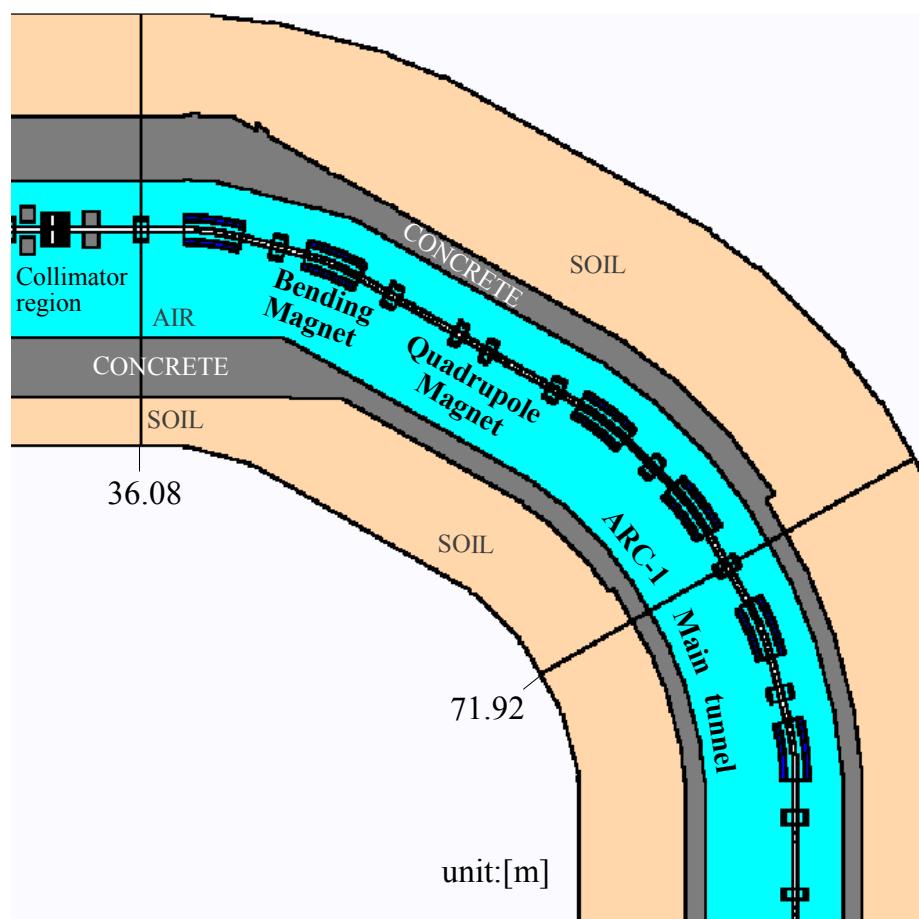


Figure 13: Horizontal cross sections of the beam line tunnel along the beam axis in the arc-1 region.

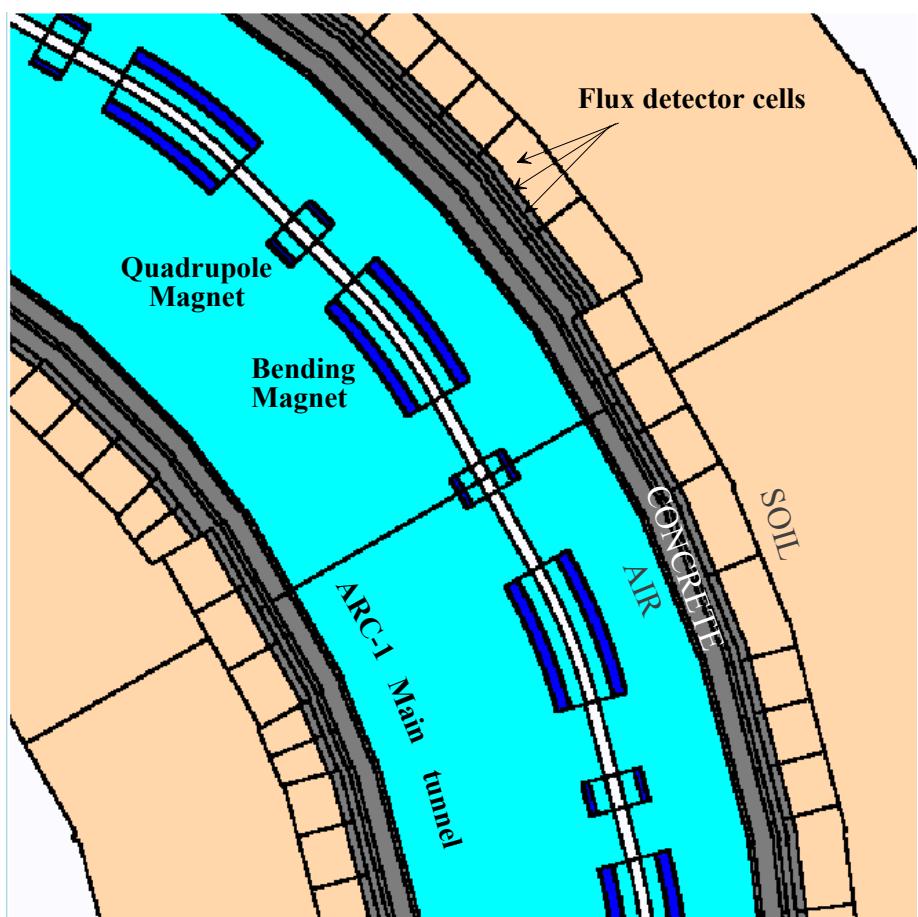
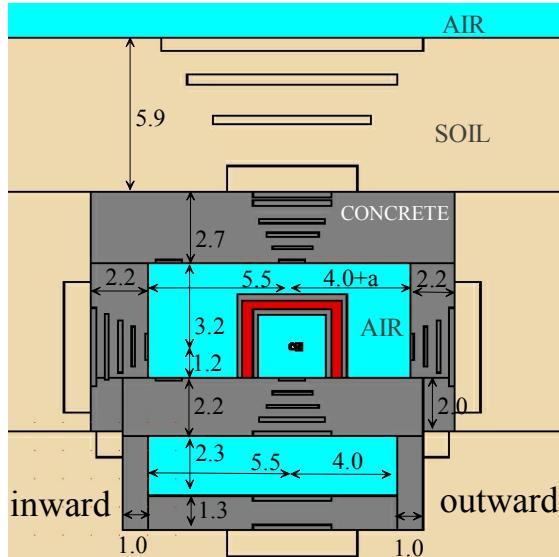
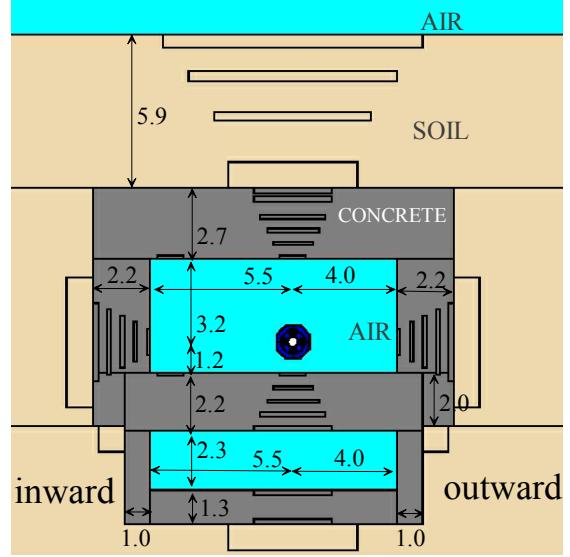


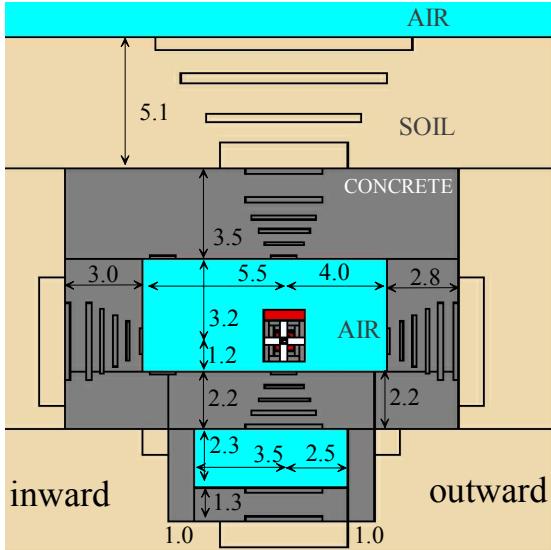
Figure 14: Flux detector cells in the horizontal cross section of the arc-1 region.



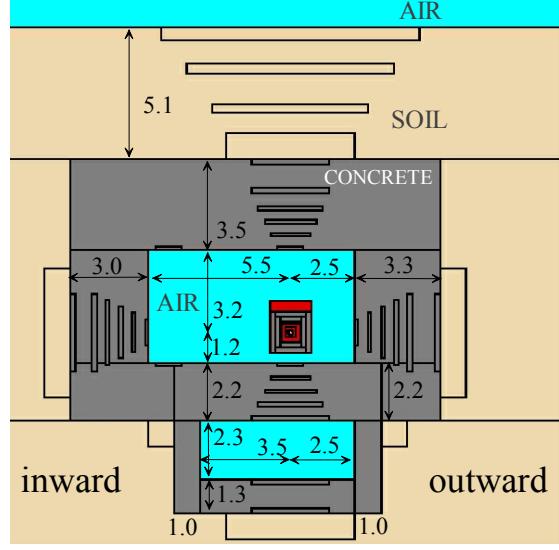
(a)



(b)



(c)



(d) unit:[m]

Figure 15: Vertical cross sections of the beam line tunnel perpendicular to the beam axis at (a) injection septum ($z=342.5\text{m}$), (b) Q-magnet after foil ($z=1.0\text{m}$), (c) collimator ($z=13.3\text{m}$) and (d) collimator ($z=20.0\text{m}$).

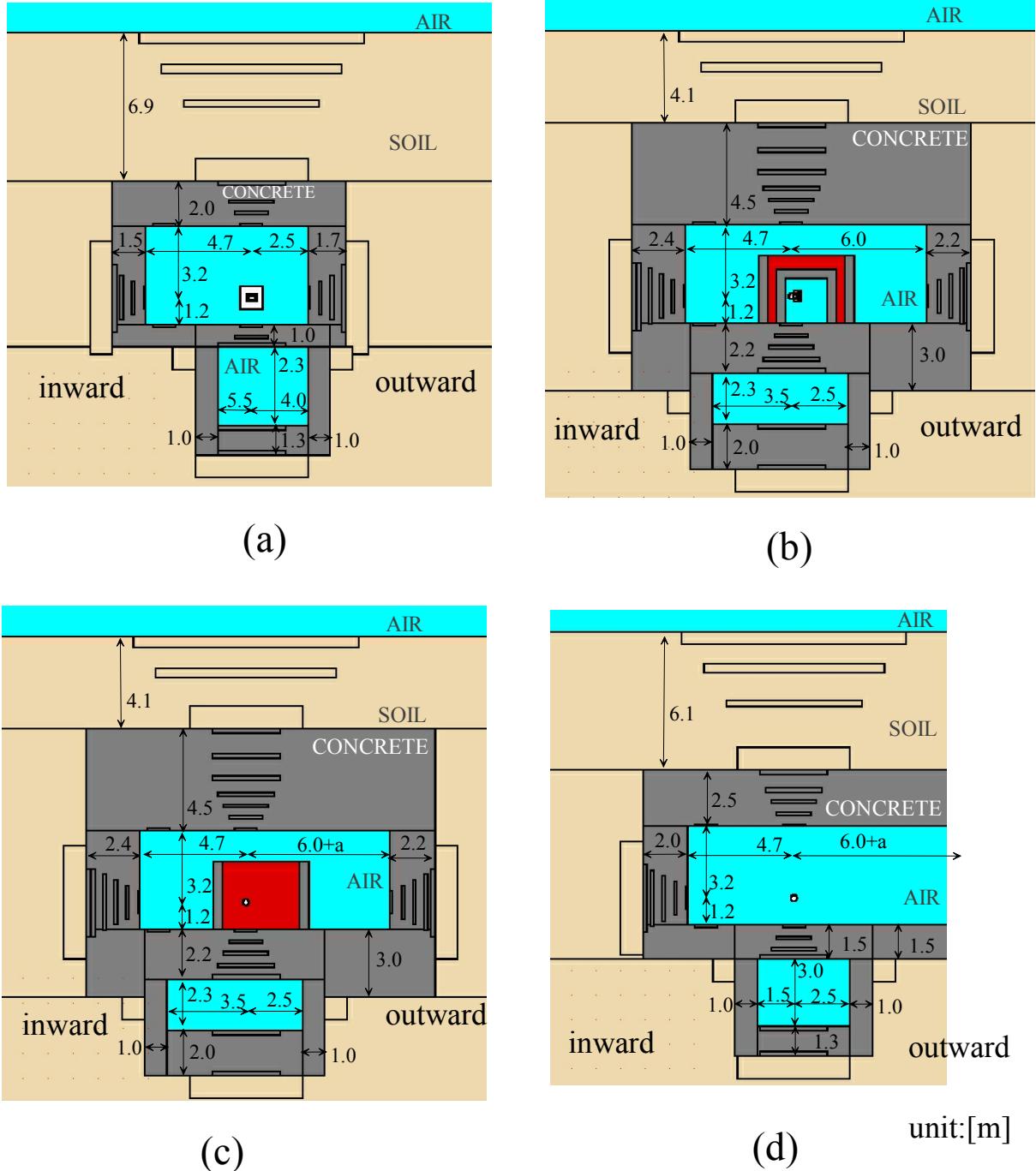


Figure 16: Vertical cross sections of the beam line tunnel perpendicular to the beam axis at (a) kicker ($z=110.5\text{m}$), (b) extraction septum ($z=126.0\text{m}$), (c) forward shield of the extraction septum ($z=136.5\text{m}$) and (d) 3NBT separation at the extraction ($z=150.0\text{m}$).

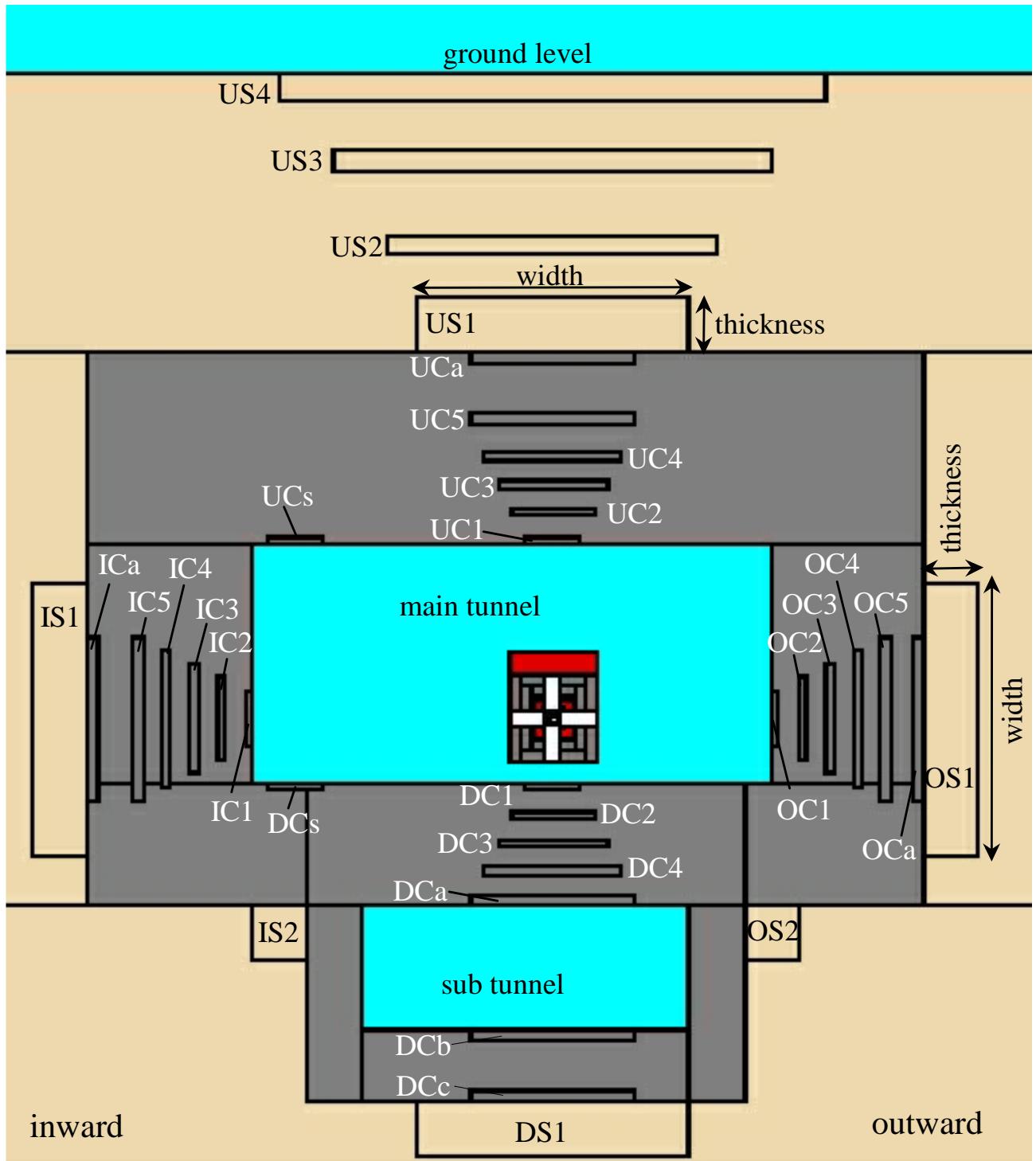


Figure 17: Flux detectors and their names used in the calculation in the vertical cross sections of the beam line tunnel perpendicular to the beam axis. (See Table 3, p.19)

Table 3: Positions and sizes for each flux detector (See Fig.17, p.18). a~q indicate the distances from the beam line which are shown in Fig.18(p.20) and tabulated in Table 4 (p.21).

Shield	Det.-No	Detector Position [cm]		Detector thickness [cm]		Detector width [cm]
<u>Upward</u>						
Concrete	UC1	From ceiling inner surface(a) (80cm inward from UC1)	+0	tun-det-thick	10.0	tun-det-width
	UCs		+0		10.0	50
	UC2	tun-indet-dist	+50	tun-indet-thick	12.5	tun-indet-width
	UC3		+100		15.0	75
	UC4		+150		17.5	100
	UC5		+220		20.0	125
	UC6		+320		20.0	150
	UCa	ceiling wall outer surface(b)		soil-det-thick	20.0	soil-det-width
Soil	US1	soil surface(b)		soil-det1-thick	100.0	soil-det1-width
	US2	From beam line	850	vert-det-thick	30.0	vert-det-width
	US3		1000		40.0	400
	US4	vert-det-height ground level(1180)	1130		50.0	500
<u>Downward</u>						
Concrete	DC1	From floor inner surface(c) (80cm inward from DC1)	+0	tun-det-thick	10.0	tun-det-width
	DCs		+0		10.0	50
	DC2	tun-indet-dist	+50	tun-indet-thick	12.5	tun-indet-width
	DC3		+100		15.0	75
	DC4		+150		17.5	100
	DCa	sub tunnel ceiling surface(i)		soil-det-thick	20.0	soil-det-width
	DCb	sub tunnel floor inner surface(j)			20.0	125
	DCc	sub tunnel floor outer surface(k)			20.0	150
Soil	DS1	soil surface(k)		soil-det1-thick	100.0	soil-det1-width
<u>Inward/Outward</u>						
Concrete	IC1/OC1	From side wall inner surface(e/g)	+0	tun-det-thick	10.0	tun-det-width
	IC2/OC2	tun-indet-dist	+50	tun-indet-thick	12.5	tun-indet-width
	IC3/OC3		+100		15.0	75
	IC4/OC4		+150		17.5	100
	IC5/OC5		+200		20.0	125
	ICa/OCa	side wall outer surface(f/h)		soil-det-thick	20.0	soil-det-width
Soil	IS1/OS1	soil surface(f/h)		soil-det1-thick	100.0	soil-det1-width
	IS2/OS2	soil surface(m/p)		soil-det1-thick	100.0	soil-det1-thick

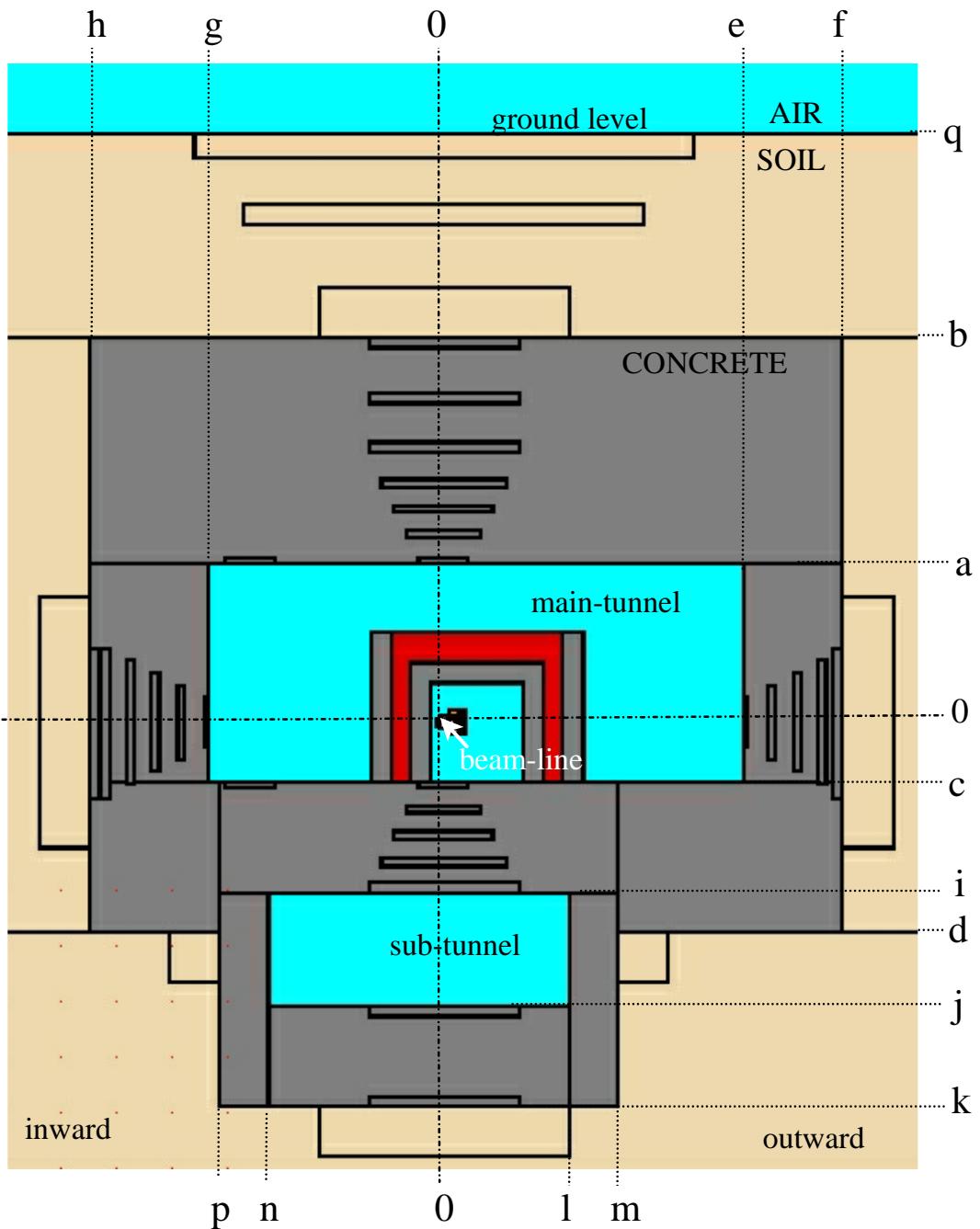
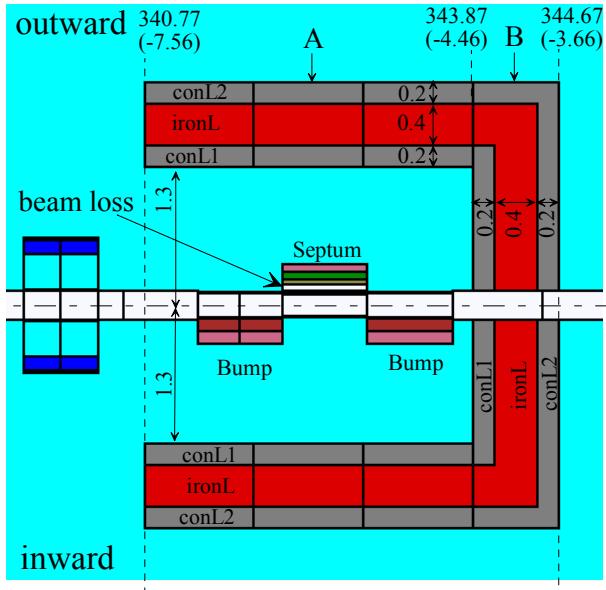


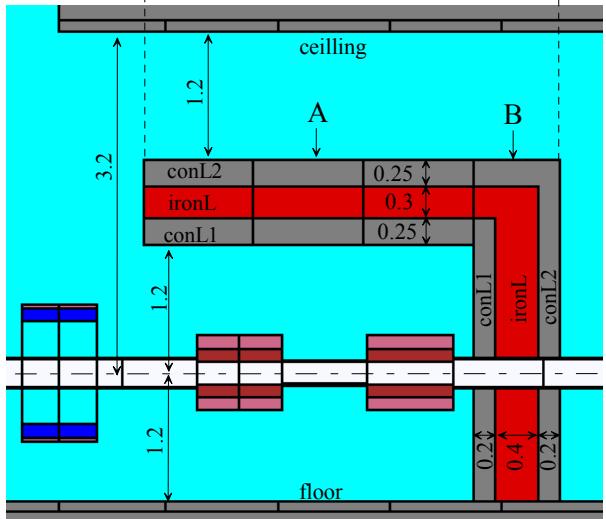
Figure 18: Coordinates in the vertical cross sections of the beam line tunnel perpendicular to the beam axis which indicate distances (a~q) from beam line to the inner and outer surfaces of the shield. (See Table 4, p.21)

Table 4: Positions of the inner (tunnel inside) and outer (soil boundary) surface of the concrete shield wall which are described in the distance(cm) from the beam line. c, j and q are omitted because of the constant values (c=-120, j=-570 and q=1180) in the whole regions. See positions of a~q in Fig.18(p.20)

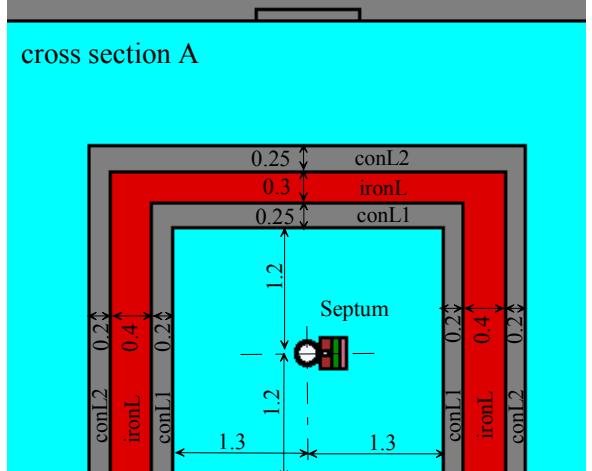
Tunnel location range (cm)	Distance from the beam line (cm)												
	Main tunnel							Sub tunnel					
	Up		Down	Outward		Inward		Up		Down	Outward		Inward
	in a	out b	out d	in e	out f	in g	out h	in i	out k	in l	out m	in n	out p
0.0 ~ 1000.0 inj to coll	320	590	-320	400	620	-550	-770	-340	-700	400	500	-550	-650
1000.0 ~ 1500.0 collimator	320	670	-340	400	680	-550	-850	-340	-700	250	350	-350	-450
1500.0 ~ 1750.0 collimator	320	670	-340	400 ~250	680	-550	-850	-340	-700	250	350	-350	-450
1750.0 ~ 3200.0 collimator	320	670	-340	250	580	-550	-850	-340	-700	250	350	-350	-450
3200.0 ~ 3723.6 collimator	320	670	-340	250	580	-550	-850	-340	-700	250	350	-350	-450
3723.6 ~ 3823.6 coll to Arc1	320	670	-340	250	580	-550	-850	-340	-700	250	350	-160	-450
3823.6 ~ 5000.0 Arc1	320	500	-220	252 ~240	585 ~390	-555 ~-460	-857 ~-580	-220	-700	240	340	-160	-260
5000.0 ~ 6997.4 Arc1	320	440	-220	240	390	-460	-580	-220	-700	240	340	-160	-260
6997.4 ~ 10581.2 Arc1	320	420	-220	240	340	-460	-560	-220	-700	240	340	-160	-260
10581.2 ~ 11860.0 Kicker	320	520	-220	250	420	-470	-620	-220	-700	250	350	-150	-250
11860.0 ~ 12060.0 Kicker	320	770	-420	250	820	-470	-710	-340	-770	250	350	-150	-450
12060.0 ~ 13400.0 Ext septum	320	770	-420	600	820	-470	-710	-340	-770	250	350	-350	-450
13400.0 ~ 14100.0 Extraction	320	770	-420	600 ~720	820 ~940	-470	-710	-340	-770	250	350	-350	-450
14100.0 ~ 14200.0 Extraction	320	770	-420	720 ~737	940 ~957	-470	-710	-340	-770	250	350	-160	-450
14200.0 ~ 15584.7 Extraction	320	570	-270	737 ~973	957 ~1193	-470 ~-454	-670 ~-656	-270	-700	250	350	-160	-260
15584.7 ~ 15734.7 Arc2	320	570	-270	240	1040	-454 ~-435	-656 ~-636	-270	-700	240	350	-160	-260
15734.7 ~ 16374.7 Arc2	320	420	-220	240	340	-447 ~-464	-653 ~-565	-220	-700	240	340	-160	-260
16374.7 ~ 21252.3 Arc2	320	420	-220	240	340	-460	-560	-220	-700	240	340	-160	-260
21252.3 ~ 21892.3 Arc2	320	420	-220	240	340	-464 ~-519	-565 ~-674	-220	-700	240	340	-160	-260
21892.3 ~ 22192.3 Arc2	320	520	-220	240	410	-505 ~-545	-656 ~-696	-220	-700	240	340	-160	-260
22192.3 ~ 27045.8 RF cavity	320	520	-220	240	410	-540	-690	-220	-700	240	340	-160	-260
27045.8 ~ 27345.8 Arc3	320	520	-220	240	410	-545 ~-505	-696 ~-656	-220	-700	240	340	-160	-260
27345.8 ~ 27985.8 Arc3	320	420	-220	240	340	-519 ~-464	-674 ~-565	-220	-700	240	340	-160	-260
27985.8 ~ 32400.0 Arc3	320	420	-220	240	340	-460	-560	-220	-700	240	340	-160	-260
32400.0 ~ 32863.4 Injection	320	850	-220	240	340	-460	-560 ~-619	-220	-700	240	340	-160	-260
32863.4 ~ 33998.4 Injection	580	850	-220	959 ~546	1119 ~706	-464 ~-550	-574 ~-770	-220	-700	220	320	-180	-280
33998.4 ~ 34098.4 Inj septum	320	850	-320	546 ~510	706 ~669	-550	-770	-340	-700	400	500	-550	-650
34098.4 ~ 34833.3 (0.0) Inj septum	320	590	-320	510 ~400	669 ~620	-550	-770	-340	-700	400	500	-550	-650



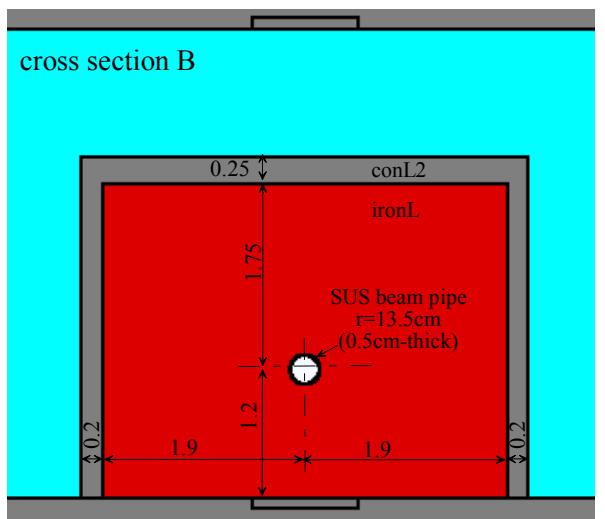
(a)



(b)



(c)



unit:[m]

Figure 19: (a) Horizontal and (b) vertical cross sections of the local shield geometry at the injection septum along the beam line, and vertical cross sections of (c) septum and (d) forward shield perpendicular to the beam line at the position of A and B in (a), respectively.

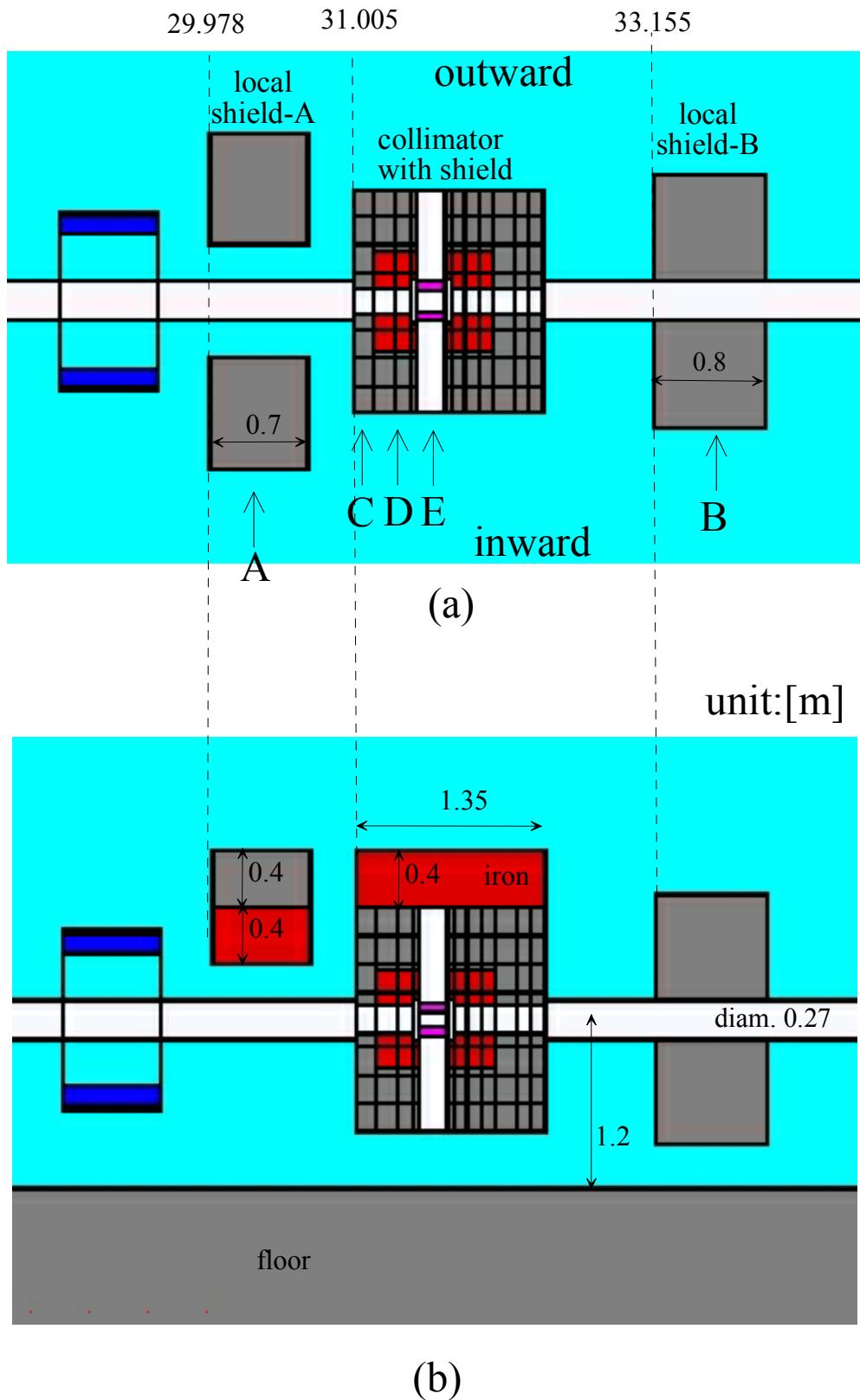


Figure 20: (a) Horizontal and (b) vertical cross sections of the local shield geometry at the collimator region along the beam line.

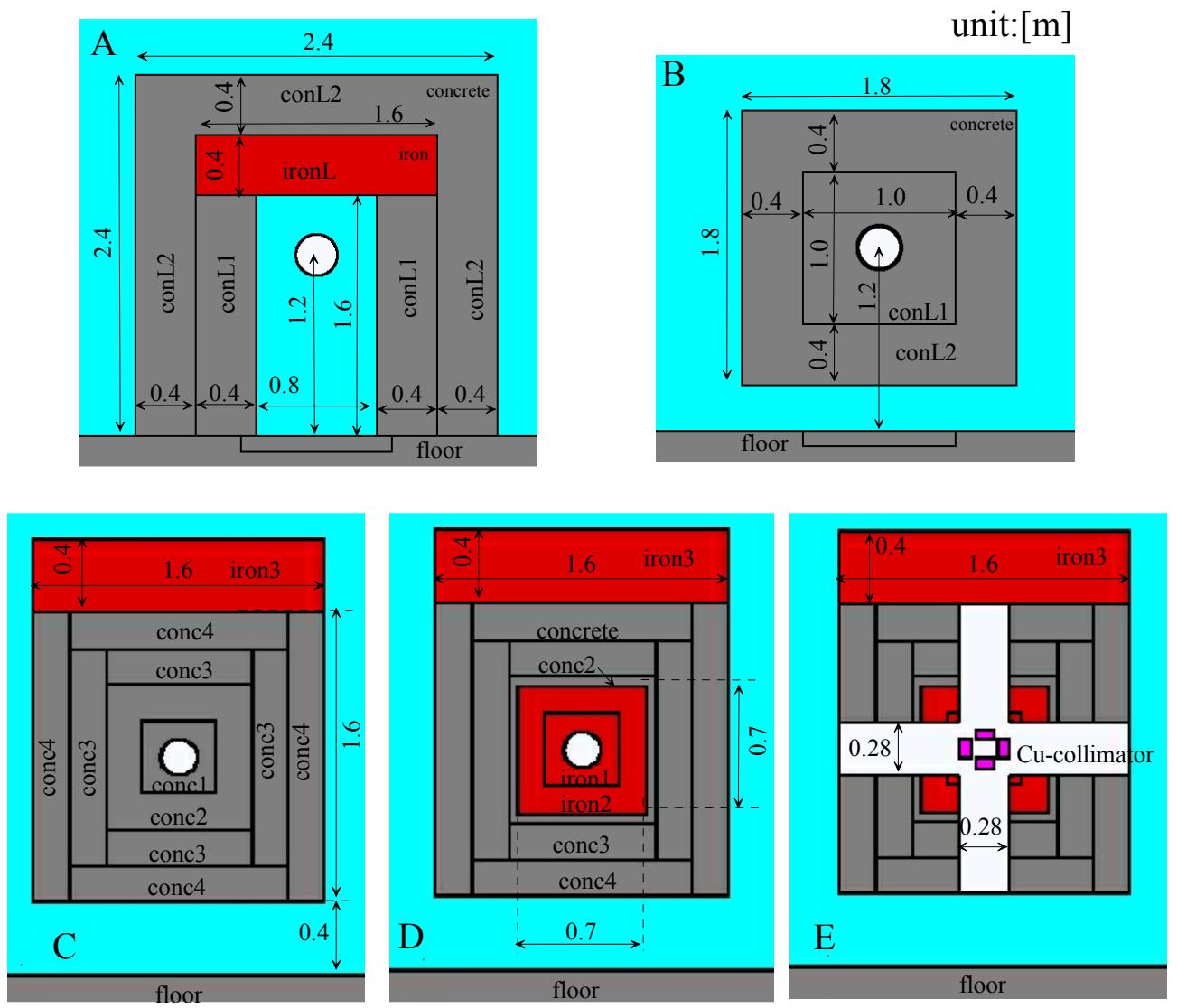


Figure 21: Vertical cross sections of the local shield at collimator region perpendicular to the beam line. A~E indicate the positions shown in Fig. 20(a)

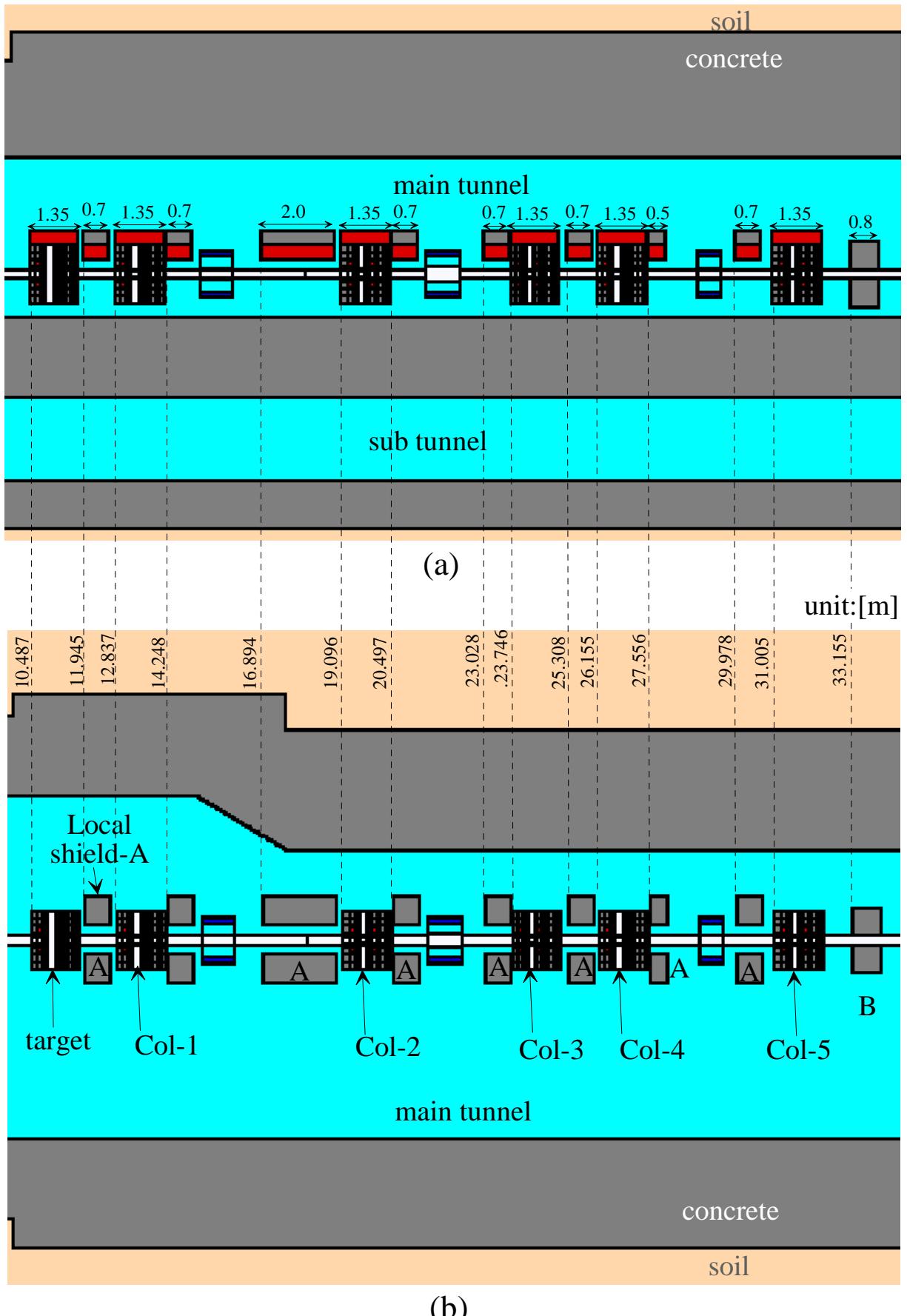


Figure 22: Locations and lengths of the local shields and the surrounding shields for target and collimators(COL1~COL5) shown in (a) horizontal and (b) vertical cross sections at the collimator region along the beam line.

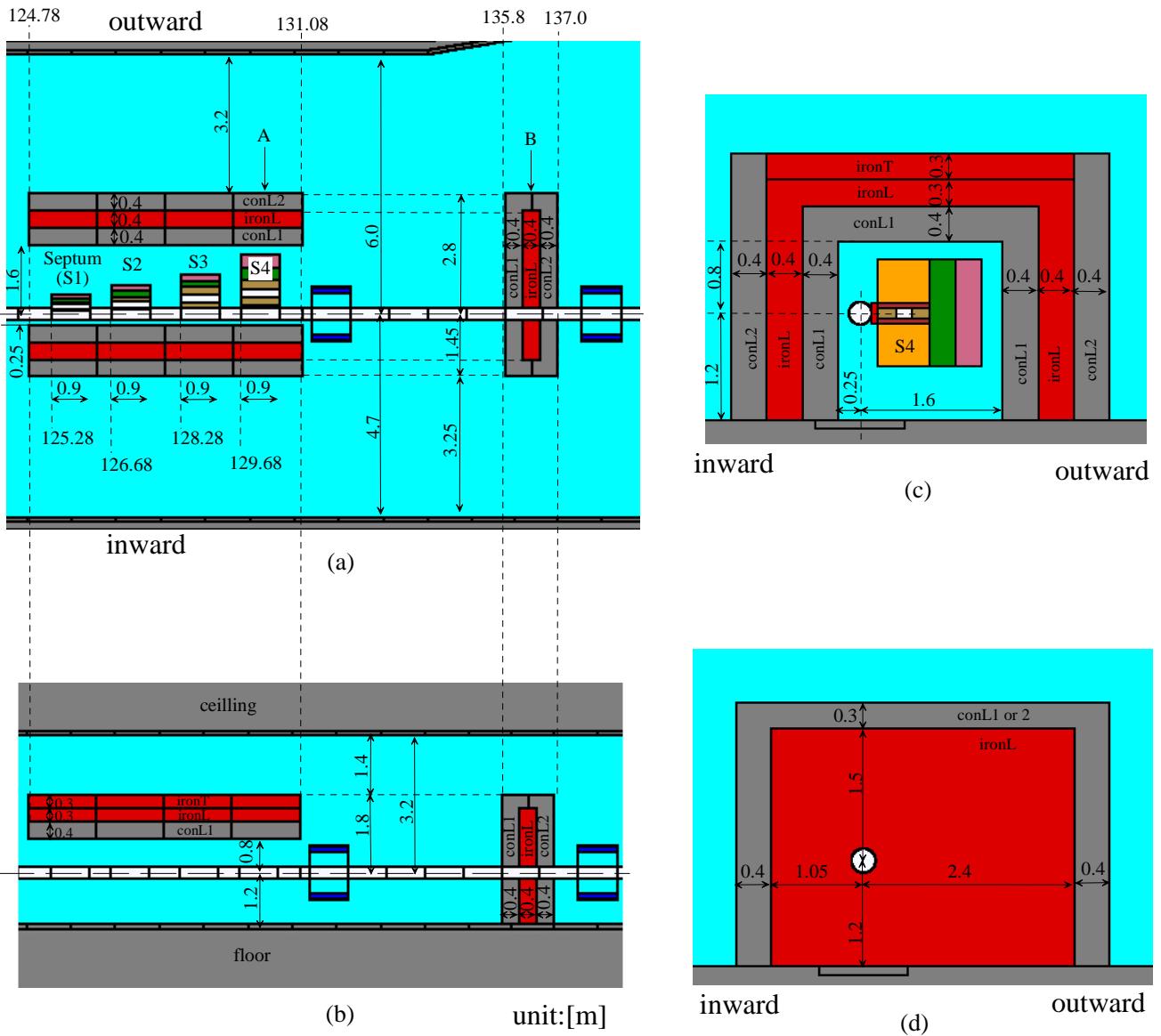


Figure 23: (a) Horizontal and (b) vertical cross sections of the local shield at the extraction septa along the beam line, and vertical cross sections of (c) septum-4 and (d) forward shield perpendicular to the beam line at the position of A and B in (a), respectively.

Bending dipole magnet

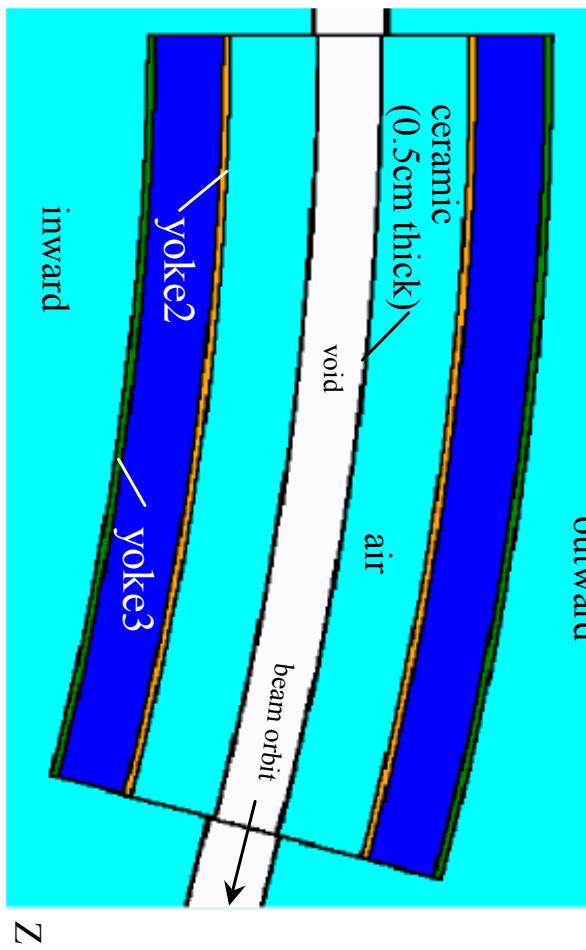


Figure 24: Horizontal cross section of bending dipole magnet.

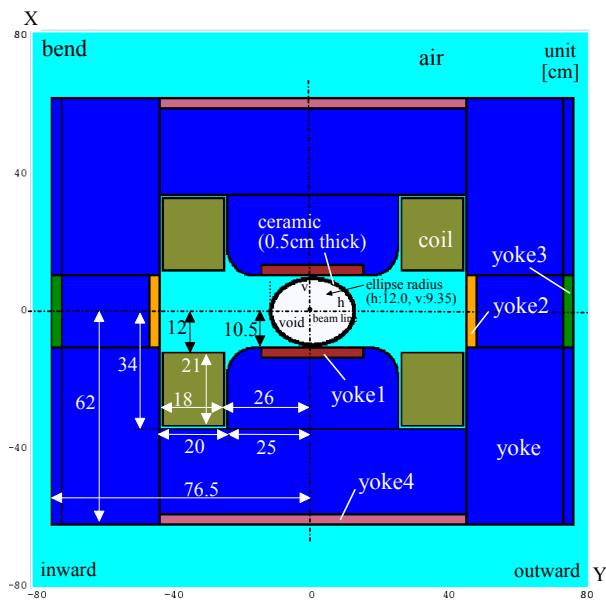


Figure 25: Vertical cross section of bending dipole magnet perpendicular to the beam line.

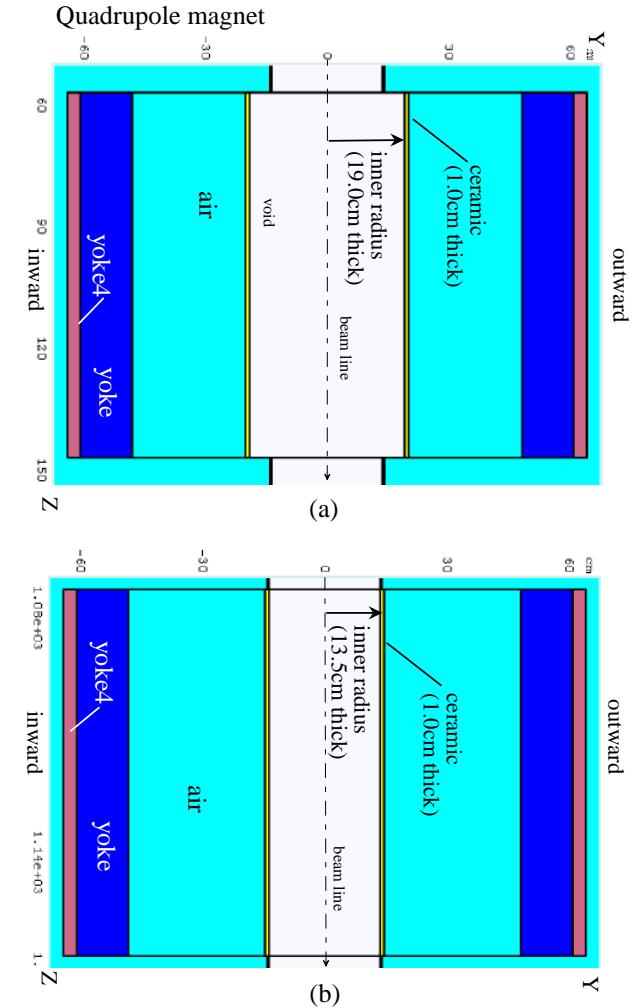


Figure 26: Horizontal cross section of quadrupole magnet. There are two types of inner radius for ceramic beam pipe such as (a) 19.0cm and (b) 13.5cm.

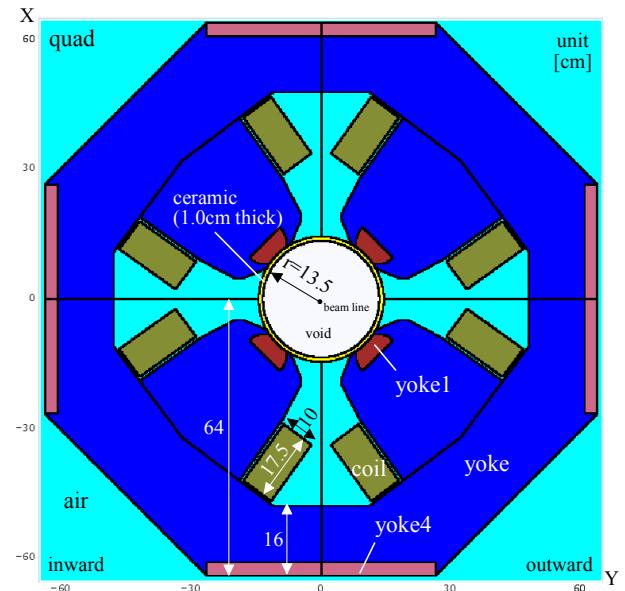


Figure 27: Vertical cross section of quadrupole magnet perpendicular to the beam line.

injection septum & bump

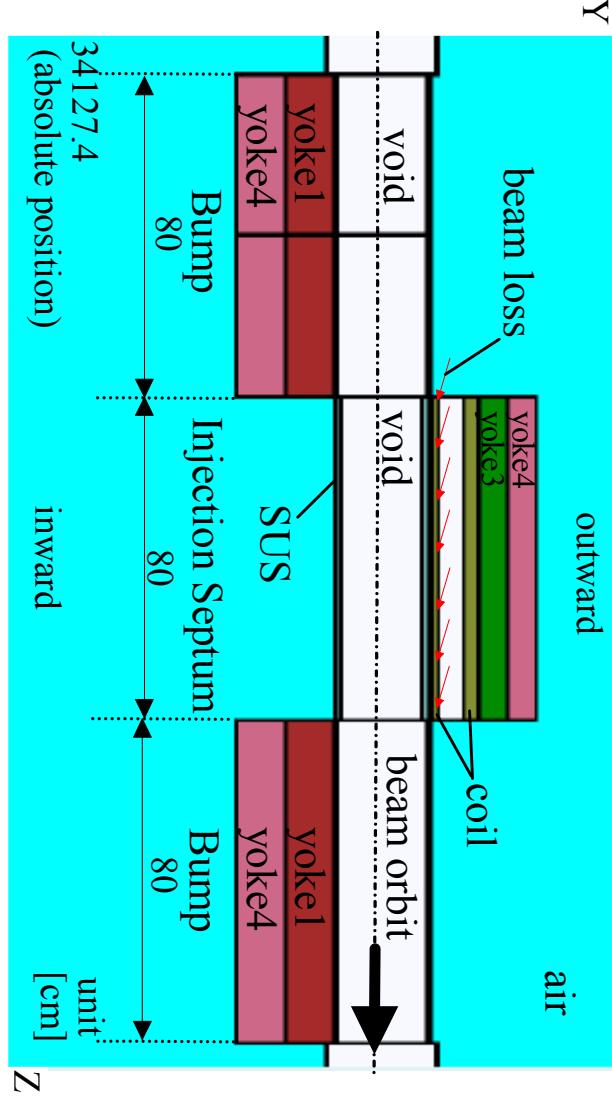


Figure 28: Horizontal cross section of injection septum and bump along the beam line.

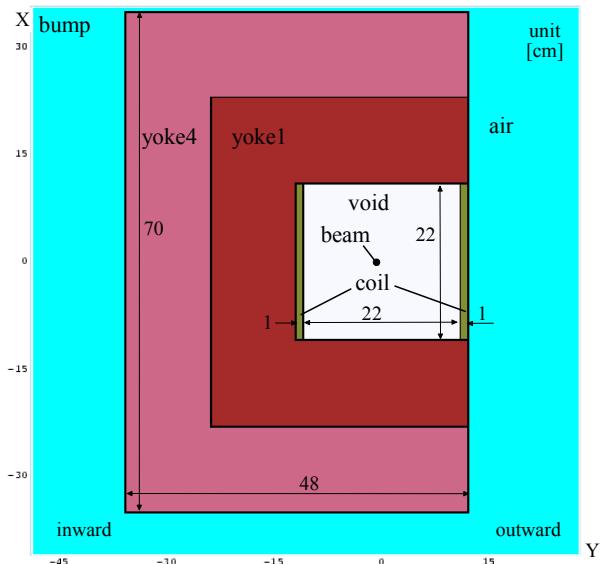


Figure 29: Vertical cross section of the bump

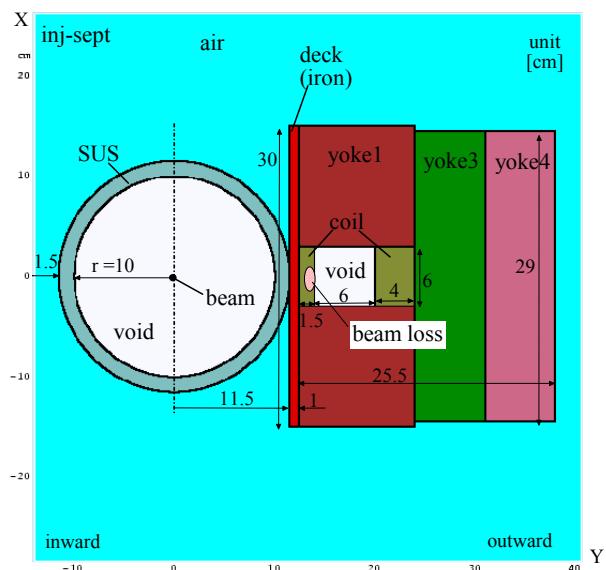


Figure 30: Vertical cross section of injection septum perpendicular to the beam line and the beam loss position as a source term.

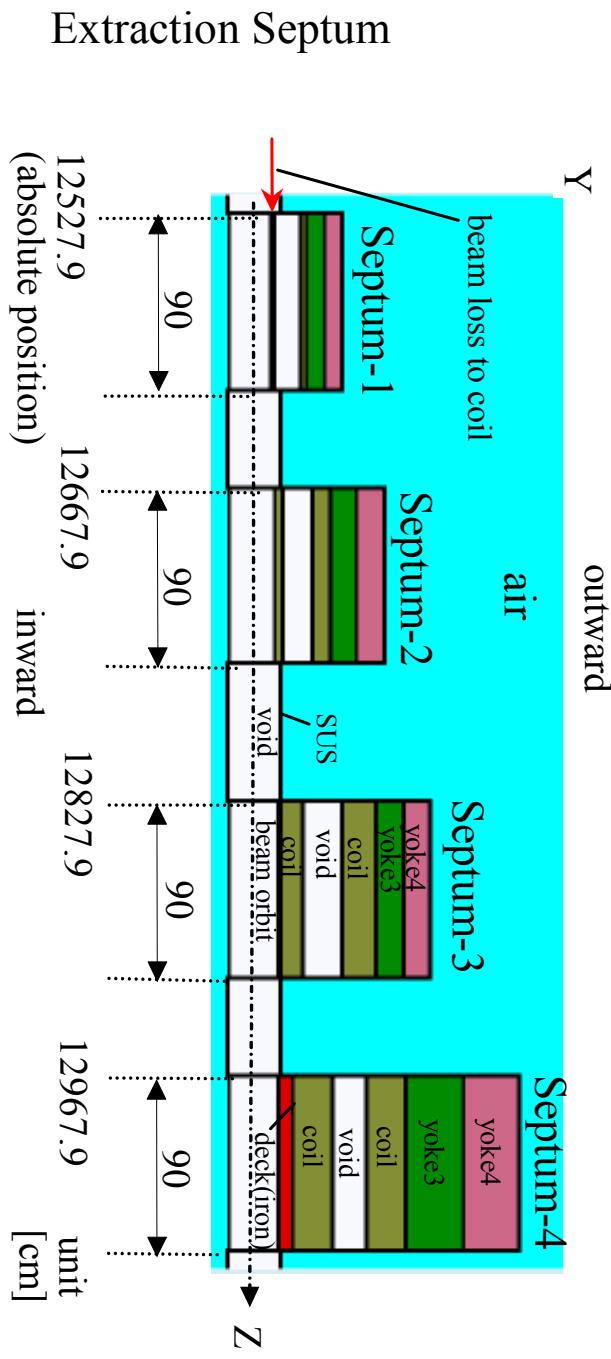


Figure 31: Horizontal cross section of extraction septa along the beam line.

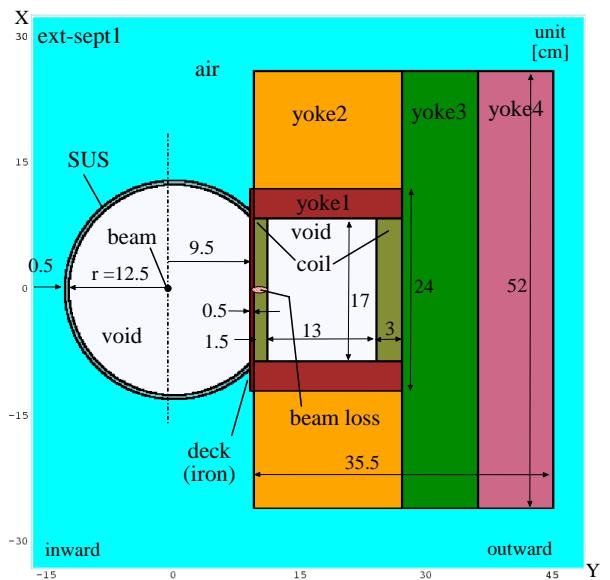


Figure 32: Vertical cross section of the extraction septum-1

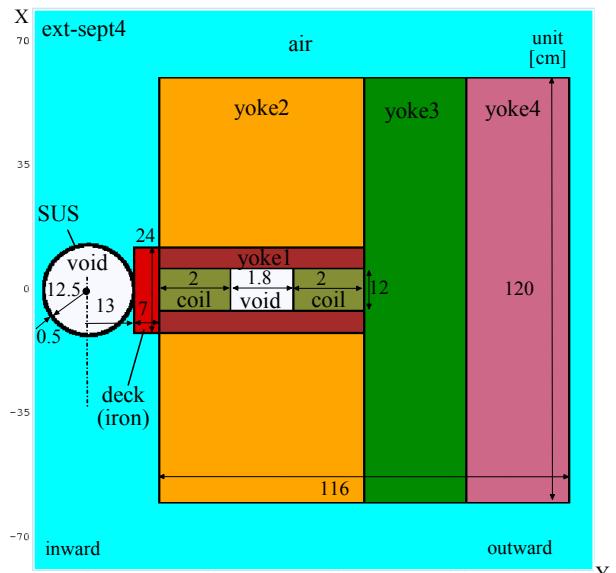


Figure 33: Vertical cross section of the extraction septum-4

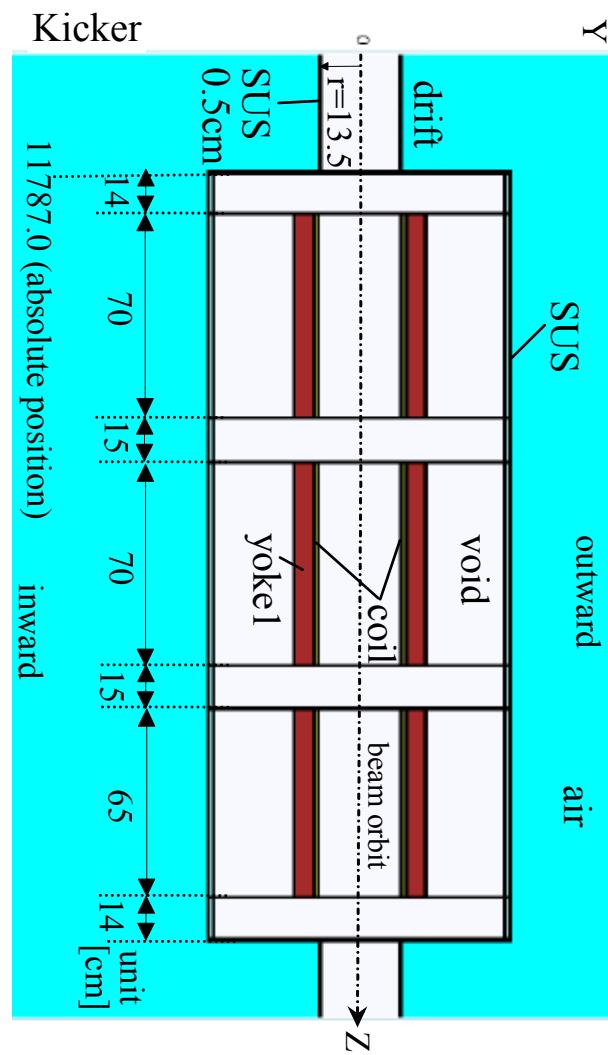


Figure 34: Horizontal cross section of kicker along the beam line

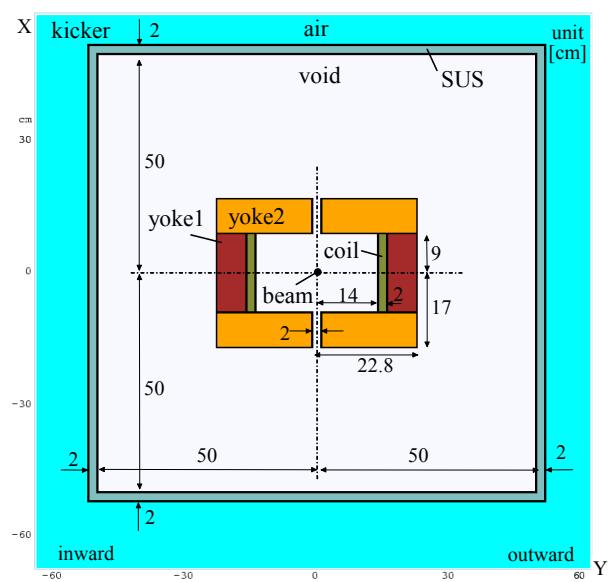


Figure 35: Vertical cross section of the kicker

5 MAKING BEAM LINE

The locations of the beam line modules and the curved tunnel structures in Fig. 13 were described by the help of the "MAD-MARS beam line builder" (MMBLB) [6, 7] prepared in the MARS code. This technique needs "OPTICS" file (see Section A.2, p. 86), which includes a list of the module informations such as name, location (end position), length, bending parameter and magnetic parameter. The "OPTICS" file is the same format used in the beam optics calculation code, MAD [8].

Calculation of a specific beam line region, in which user is interested, can be carried out by choosing a part of the list in OPTICS file. In this work, two regions of the injection through collimator (-8.3~71.3m) and the kicker though extraction (109.6~168.6m), were selected and were independently calculated.

6 MAGNETIC FIELD

The 2-dimensional magnetic fields at the dipole and quadrupole magnets, calculated with the POISSON code [9], were taken into account through the magnet regions. Fig. 36(a) and (b) show the GUI graphic views by MARS14 code for the directions and the strengths of the magnetic field in the bending dipole and quadrupole magnets, respectively. Three types of magnetic field tables are read and 2-dimensional fields are prepared in the user subroutines written in Section B.6 (p.121) for bending, focusing and defocusing magnets. The magnetic field location along the beam line are defined by the OPTICS file.

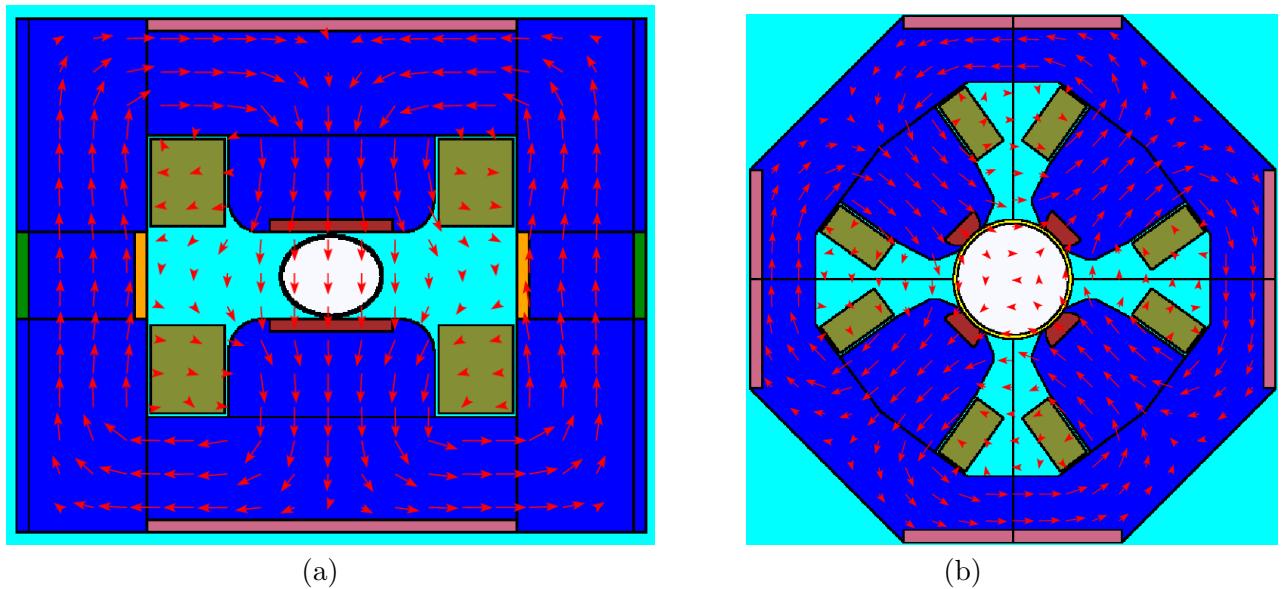


Figure 36: Magnetic field view at (a) the bending dipole magnet (b) quadrupole magnet

7 3D MULTI-LAYER TECHNIQUE FOR DEEP PENETRATION

In order to obtain good statistics of particles fluxes and doses up to the ground level through thick concrete and soil shields with a reasonable computing time in the Monte-Carlo simulation, a three-dimensional multi-layer technique was developed [10, 11] in the MARS14 calculation. As shown in Fig. 37, the shielding geometry was three-dimensionally divided into several layers of about 2~3-m thickness, and a step-by-step calculation was carried out to multiply the number of leaked particles at the boundaries between the layers.

In Fig. 37, first layer(a) includes the beam line modules and inner part of the tunnel wall, and the proton source (beam loss) was injected into the corresponding position (see Section 4.7, p.8) in the beam line. The region outside the layer is defined as blackhole where the Monte Carlo trace are terminated, and the informations of position(x,y,z), vector(dx,dy,dz), energy(E) and weight(W) of the particle are stored in the file. Second layer(b) of Fig. 37 includes the outside tunnel shield in addition to the first layer(a). Previous layers are also taken into account for considering the backscattered particles. About 10 times number of particles leaked from the previous layer were used as a source for next layer, like a splitting method. The initial weight of the particle in the new layer, W_2 , is given as

$$W_2 = \frac{N_{1_leak}}{N_1} W_1, \quad (1)$$

where W_1 is the weight of the particle leaked from the previous layer, N_1 is the number of source particle in the previous layer and N_{1_leak} is the number of particle leaked in the previous layer. The informations of leaked particles from the second layer were also stored in the files as a source for 3rd layer (c). In the final layer(d) of Fig. 37, only soil above the tunnel was taken into account to trace the particles around the ground level. Estimated physical quantities such as particle fluxes and doses for all layer calculation steps were summed in the same detector cells, and final results in each cell were obtained.

Source terms for injection, collimator region and extraction for the first layer and leaked particle sources for the outer layers are controlled in the subroutine BEG1, given in Section B.7 (p.122). Informations of the particles leaked from the geometry boundary are written in the file by the "subroutine LEAK" in Section B.8 (p.124). The boundaries of each layer are determined by the definition of a blackhole using the parameter of

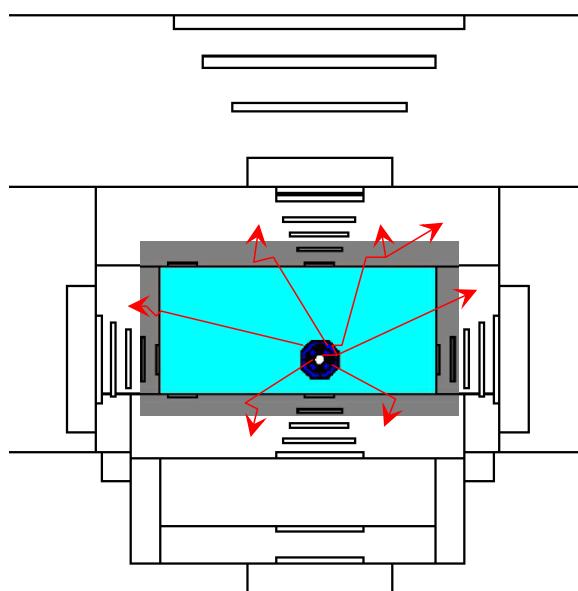
ioutflag=1

in the "subroutine XYOUT" which is called from tunnel geometry subroutine. An example of the "subroutine XYOUT" is given in Section B.3.5 (p.104).

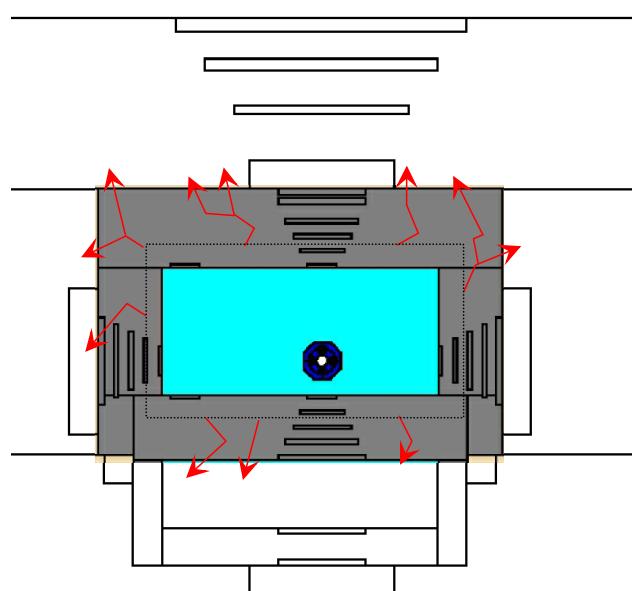
8 FLUX AND DOSE CALCULATION

In the MARS14 code, the particle fluxes are calculated using the particle track lengths across the detector volume, and prompt doses are calculated with the thus obtained energy-dependent flux multiplied by the ICRP51 flux-to-dose conversion factors [12] for corresponding particle types. Contributions from protons, neutrons, pions and photons are dominant for the prompt dose.

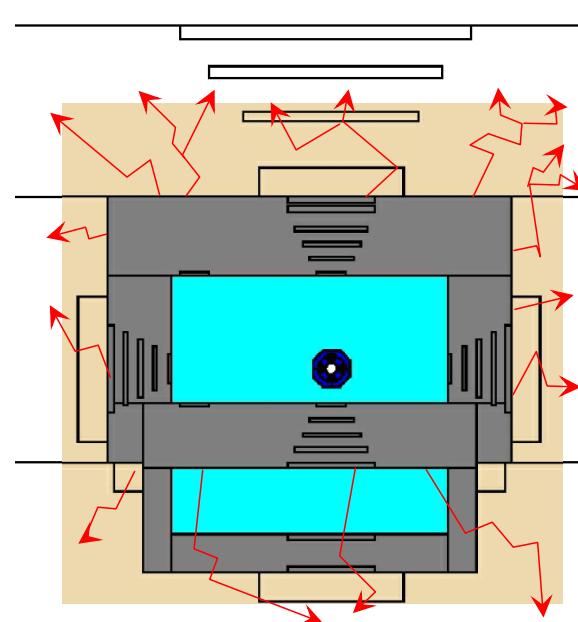
Residual dose rates obtained in the MARS14 code are those at a material surface after 30-day operation and 1-day cooling. A substantially improved ω -factor based algorithm [2, 13] to calculate residual dose rates in arbitrary composite materials for arbitrary irradiation and cooling times is used. The algorithm distinguishes three major energy groups responsible for radionuclide production: (1) above 20 MeV, (2) 1 to 20 MeV, and (3) below 0.5 eV. Corresponding dose rates on the outer surfaces are calculated from photon fluxes and related to the star density above 20 MeV (first group), and neutron fluxes in two other energy groups.



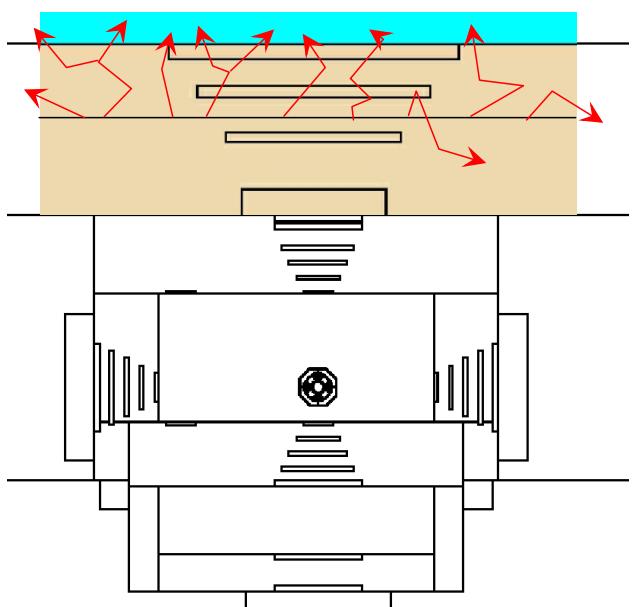
(a)



(b)



(c)



(d)

Figure 37: Calculation geometries and particle traces on the 3 dimensional multi-layer technique for deep penetration; (a) 1st layer - beam line module and tunnel inside shield, (b) 2nd layer - tunnel outside shield, (c) 3rd layer - soil around tunnel, and (d) last layer - soil and air near ground level.

9 NORMALIZATION FOR PHYSICAL QUANTITIES

In the MARS calculation in this work, normalization factors of the initial WEIGHT[proton] and the AINT[proton/sec] were set to be 1.0 for both, and later MARS output results were multiplied by source particle intensity given in Table 1(p. 3). These two normalization factors were defined in the input file of "MARS.INP" (see Section A.1, p.86). WEIGHT is defined as

INIT 7=1.0

and this definition can be omitted because of the default value. AINT is defined as

VARS 4=1.0

and this must be put because the default value is 10^{12} [p/sec].

Physical quantities in all detector cells were obtained from "MTUPLE_NON" which is one of the output files in the case when using non-standard geometry. After MARS calculation finished, energy deposition(ED), prompt dose(DEQ) and residual dose rate(PGAM) picked out from the "MTUPLE_NON" were multiplied by factors given in Table 5. Finally absorbed, prompt and residual dose rates were predicted for the actual machine operations. Since the calculations in this work were performed above 20 MeV, prompt dose was multiplied by 2.0 to obtain the total dose because neutron energy spectrum behind thick concrete or soil shield is $1/E$ shape and the ratio of total to high energy neutron dose is approximately 2.0. Besides, the safety factor of 2.0, which includes uncertainties of the assumptions on the beam loss, geometry and some other unknown factors in the actual operation, was introduced for the prompt dose rates for the shielding thickness estimation.

Table 5: Physical quantities from MARS calculation output and used normalization factors

MARS normalization	WEIGHT 1.0 [proton]		AINT 1.0 [proton/sec]
MARS output	Energy Deposition ED [GeV/g]	Prompt Dose DEQ [mSv]	Residual Dose Rate PGAM [mSv/h]
Factor	1.602×10^{-7} [Gy/(GeV/g)]	3600 [sec/h]	-
	-	(Total)/(High Energy) 2.0	-
	-	Safety factor 2.0	-
	Source particle number of Table 1 [proton/sec]		
Final Result	Absorbed Dose Rate [Gy/sec]	Prompt Dose Rate [mSv/h]	Residual Dose Rate [mSv/h]

10 DOSE REGULATIONS FOR SHIELDING DESIGN

The thicknesses of the concrete shield walls of the tunnel were determined based on the calculated prompt dose rate at the concrete-soil boundary and the ground level. The regulations of prompt dose rate for the shielding design of J-PARC are, given in Table 6, 5 mSv/h and 11 mSv/h in prompt dose rate for a distributed beam loss and for a localized beam loss, respectively, at the soil at the boundary of concrete tunnel outside to avoid the ground water activation, and those at the uncontrolled area such as ground level is $0.25 \mu\text{Sv}/\text{h}$ in prompt dose rate.

Table 6: Regulations of prompt dose rate for the shielding design of J-PARC.

	Localized beam loss	Distributed beam loss
Soil-Concrete Boundary	11 mSv/h	5 mSv/h
Ground Level (Uncontrolled Area)	$0.25 \mu\text{Sv}/\text{h}$	

11 RESULTS AND DISCUSSIONS

11.1 Prompt dose rate and shield thickness estimation

Shield thickness of tunnel wall and local shields were finally determined by these prompt dose rate distributions calculated by MARS14 code. The calculated prompt dose rate distributions inside the concrete and soil shield in four directions of up, down, inward and outward are shown in Figs. 38~41 for the injection through collimator region and in Figs. 42~45 for the kicker through extraction region. The numerical data are given in Tables 7 and 8. These figures show the beam loss distribution in the corresponding regions together with the vertical or horizontal tunnel structure, the beam line module location and the aperture structure. Positions and sizes of the flux detectors(UC1, UC2, etc.) are shown in Fig. 17 (p.18) and tabulated in Table 3 (p.19).

For injection and collimator region, although the beam losses of the septum, target and 5 collimators are dominant, the local shields at these areas attenuated prompt dose rates. As shown in Fig. 38, prompt dose rate at inner surface of beam line tunnel (UC1) has a peak after the 1st collimator (COL1) because of the forward scattering at the target and COL1. The US1 soil detectors are at the soil-concrete boundary just above the thick concrete shield at the ceiling. As seen in Fig. 38, the prompt dose rate distribution of US1 which is shown as red double circles are much lower than 5 mSv/h in the collimator region and 11 mSv/h in the injection region which are the regulations at the soil-concrete boundary for distributed beam loss and for localized beam loss, respectively. However, these thick concrete shields are inevitable for the distribution of US4 shown as blue circles to satisfy the regulation at the ground level as uncontrolled area, 0.25 μ Sv/h. Fig. 39 shows the prompt dose rate at floor and sub-tunnel direction. Because of no local shield below the beam line, dose rates at the floor surface (DC1) are much higher than those at UC1 in Fig. 38. However, the prompt dose rate distribution of DS1, which is the soil region blow the sub-tunnel floor concrete shield, satisfy the regulation. Fig. 40 and Fig. 41 show the prompt dose rate at inward and outward directions, respectively. At the side soil-concrete boundary of IS1 and OS1, and also at the corner boundary of IS2 and OS2, prompt dose rates satisfy the regulation.

In the kicker through extraction region, 1 kW beam loss is defined only at inner coil surface of the septum-1, and local shields are equipped around the four septa and at downstream as shown in Fig. 23. In Fig. 45, high prompt dose rate of 8.33 mSv/h is found at the OS1 detector cell in the region from 157.347 to 159.047m, which is located at cell-A in Fig. 12. It is due to the hadron shower from the extraction septum through the shield wall B in Fig. 12. However, at the concrete-soil boundary of US1, DS1, IS1, IS2, OS1 and OS2 and also at the ground level of US4 in Figs. 42~45, the prompt dose rates satisfy the regulation of 11 mSv/h and 0.25 μ Sv/h, respectively.

Prompt dose rate at the various parts of the local shields and the beam line modules were also estimated. The numerical data are tabulated in Tables 9, 10 and 11 for the injection through collimator region, the kicker through extraction region, and local shields, respectively.

11.2 Residual dose and absorbed dose near beam line

Figs.46 and 47 show the calculated residual dose rate distributions at beam line modules, the tunnel inner concrete shield wall and local shields together with the beam loss distribution in the corresponding regions, the horizontal tunnel structure, the machine module location and the aperture structure. The numerical data of residual dose rates at material suface are given in Tables 12~16. These residual dose rates are under an assumption of 30-day operation and 1-day cooling.

As shown in the distributions of beam line module in Figs.46 and 47, several parts of the modules, such as the septum coil, copper collimators, iron shields and beam pipe near the collimator, exceed 1 Sv/h, which is too high for maintenance. At the injection septum, however, the design of a new injection scheme [14] is then in progress in order to provide enough separation of the incoming and circulating beams, resulting in a considerably lower beam loss than 1 kW.

The calculated absorbed dose rate distributions of the tunnel inner shield wall, local shield and beam line modules are also estimated and the numerical data are given in Tables 17~21. These results are useful to estimate radiation damages of materials and instruments.

INJECTION

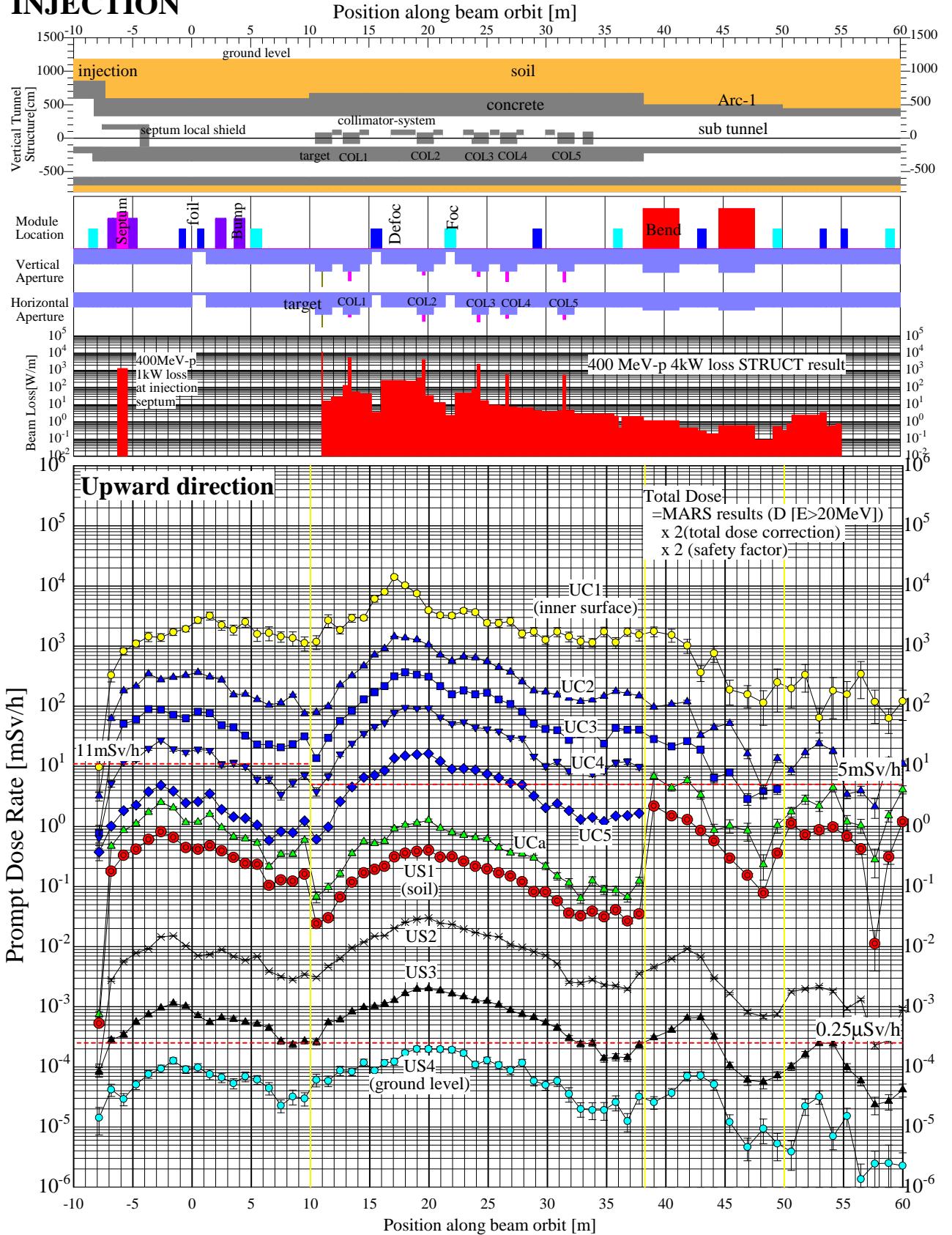


Figure 38: Calculated prompt dose rate distributions inside the shield of the ceiling wall through the ground level in the region from the injection through the collimator. The numerical data are given in Tables 7. Vertical shield structure, machine module location, aperture structure and beam-loss distribution are also shown in the same region. Positions and sizes of the flux detectors(UC1~US4) are shown in Fig. 17 (p.18) and tabulated in Table 3 (p.19).

INJECTION

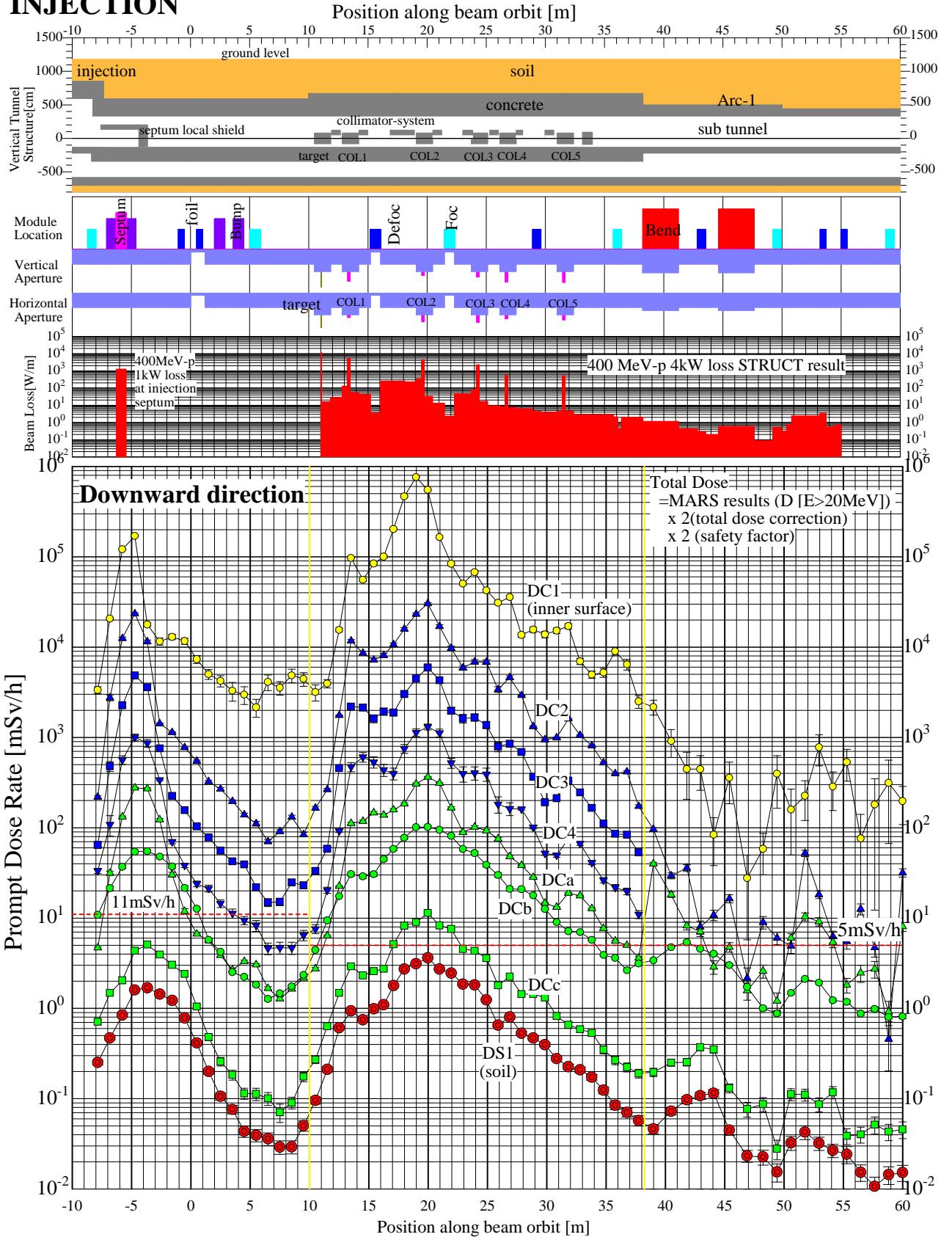


Figure 39: Calculated prompt dose rate distributions inside the shield of the foor in the region from the injection through the collimator. The numarical data are given in Tables 7. Vertical shield structure, machine module location, aperture structure and beam-loss distribution are also shown in the same region. Positions and sizes of the flux detectors(DC1~DS1) are shown in Fig. 17 (p.18) and tabulated in Table 3 (p.19).

INJECTION

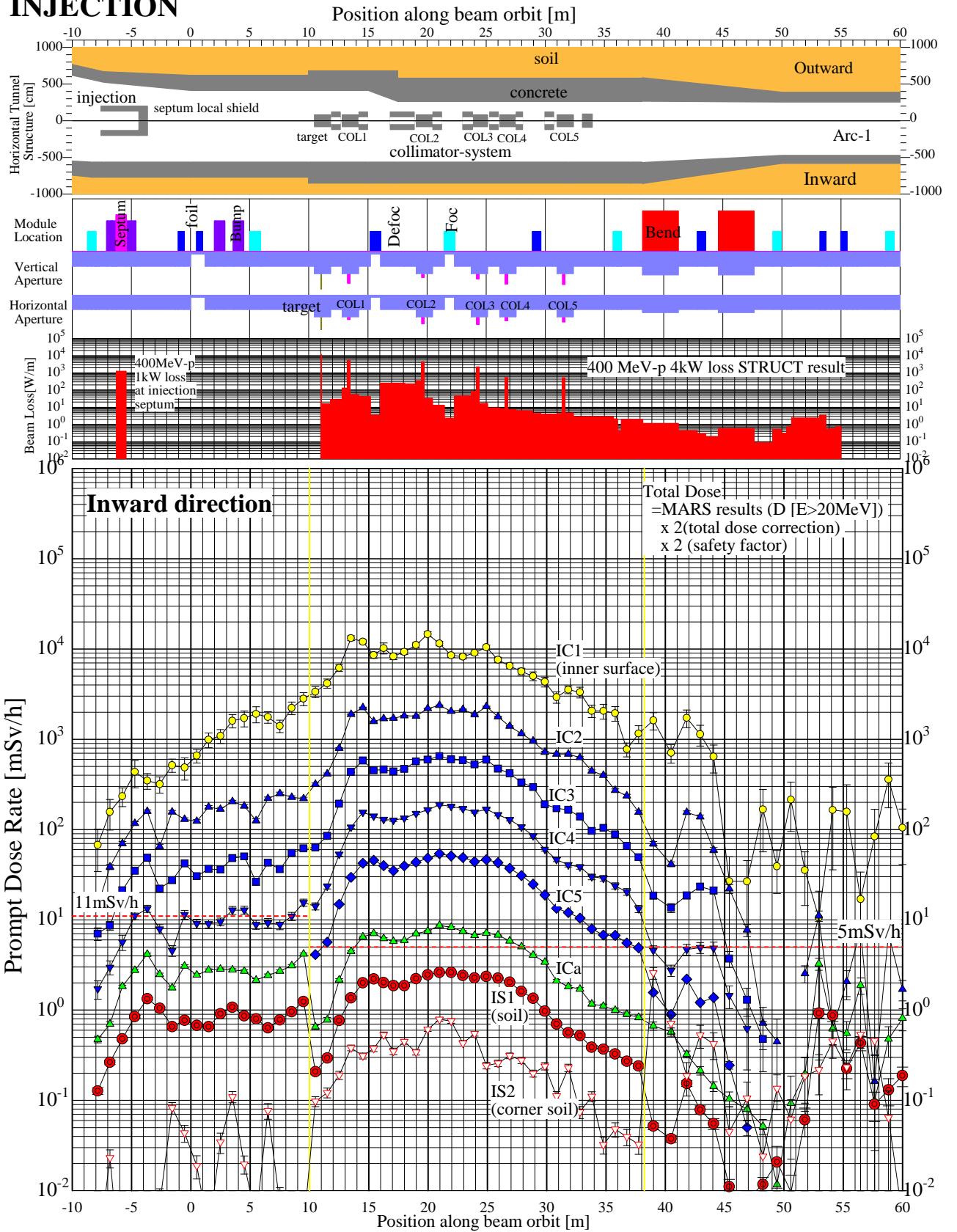


Figure 40: Calculated prompt dose rate distributions inside the shield of the ring inward direction in the region from the injection through the collimator. The numerical data are given in Tables 7. Vertical shield structure, machine module location, aperture structure and beam-loss distribution are also shown in the same region. Positions and sizes of the flux detectors(IC1~IS2) are shown in Fig. 17 (p.18) and tabulated in Table 3 (p.19).

INJECTION

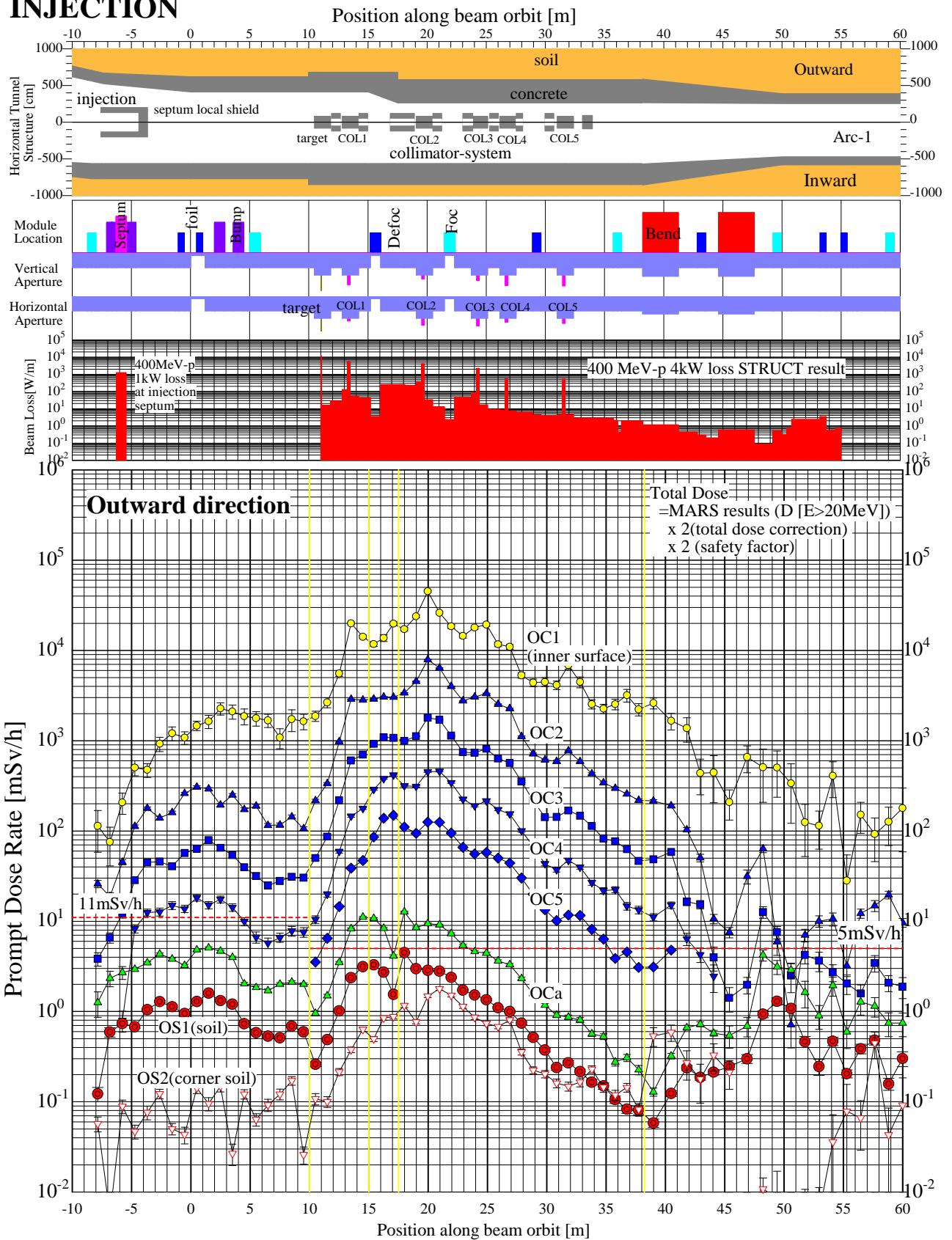


Figure 41: Calculated prompt dose rate distributions inside the shield of the ring outward direction in the region from the injection through the collimator. The numerical data are given in Tables 7. Vertical shield structure, machine module location, aperture structure and beam-loss distribution are also shown in the same region. Positions and sizes of the flux detectors(OC1~OS2) are shown in Fig. 17 (p.18) and tabulated in Table 3 (p.19).

EXTRACTION

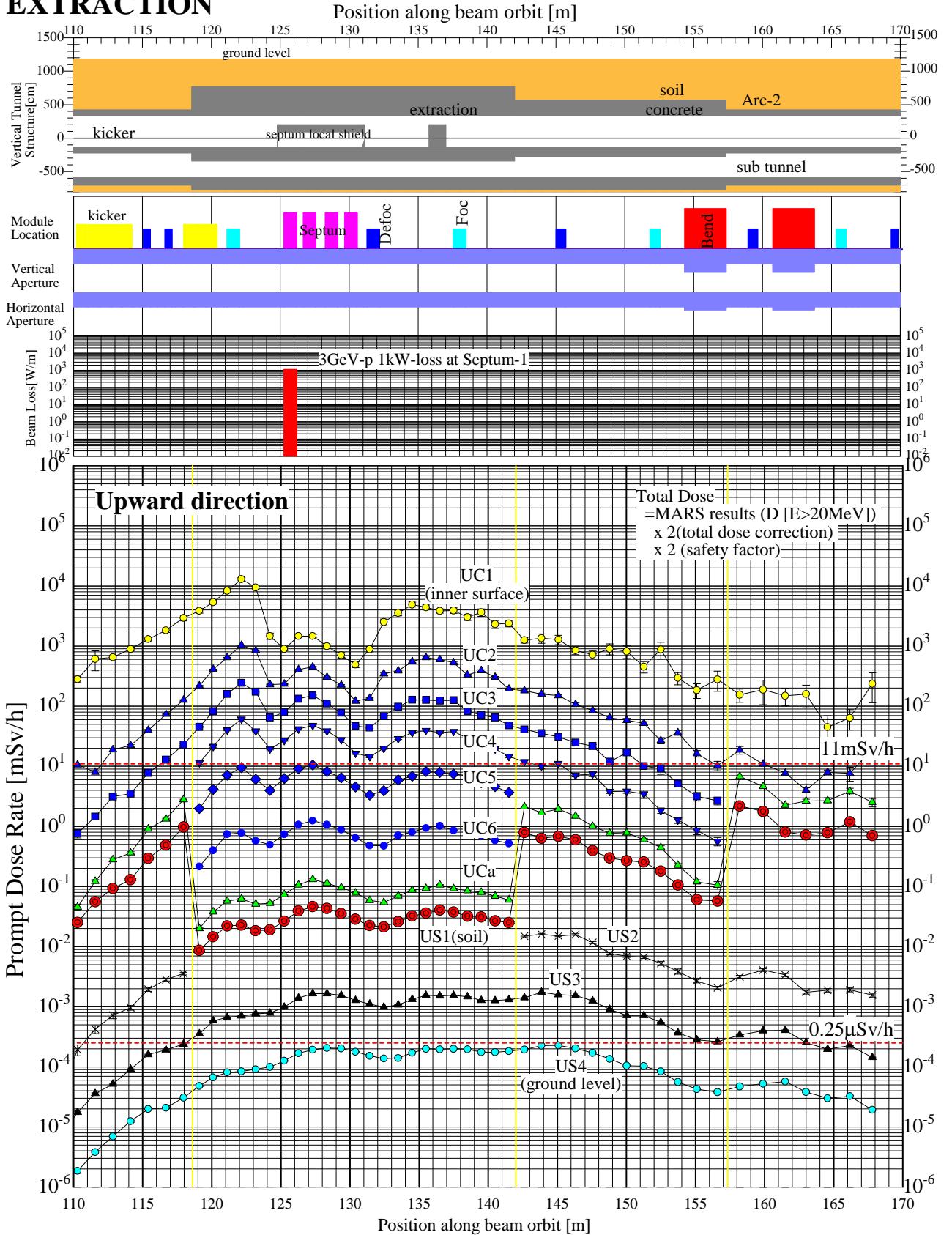


Figure 42: Calculated prompt dose rate distributions inside the shield of the ceiling wall through the ground level around the extraction region. The numerical data are given in Tables 8. Vertical shield structure, machine module location, aperture structure and beam-loss distribution are also shown in the same region. Positions and sizes of the flux detectors(UC1~US4) are shown in Fig. 17 (p.18) and tabulated in Table 3 (p.19).

EXTRACTION

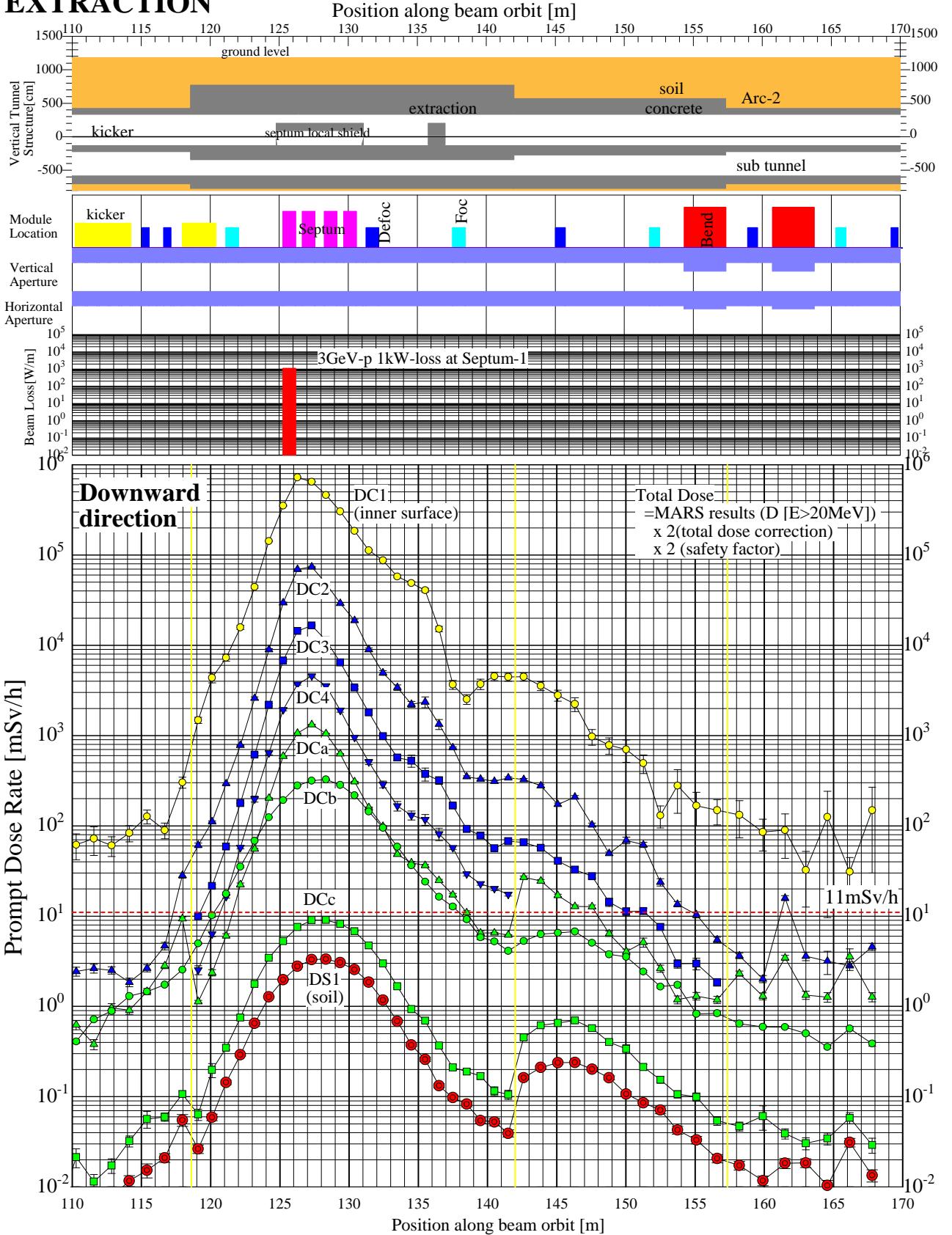


Figure 43: Calculated prompt dose rate distributions inside the shield of the foor around the extraction region. The numarical data are given in Tables 8. Vertical shield structure, machine module location, aperture structure and beam-loss distribution are also shown in the same region. Positions and sizes of the flux detectors(DC1~DS1) are shown in Fig. 17 (p.18) and tabulated in Table 3 (p.19).

EXTRACTION

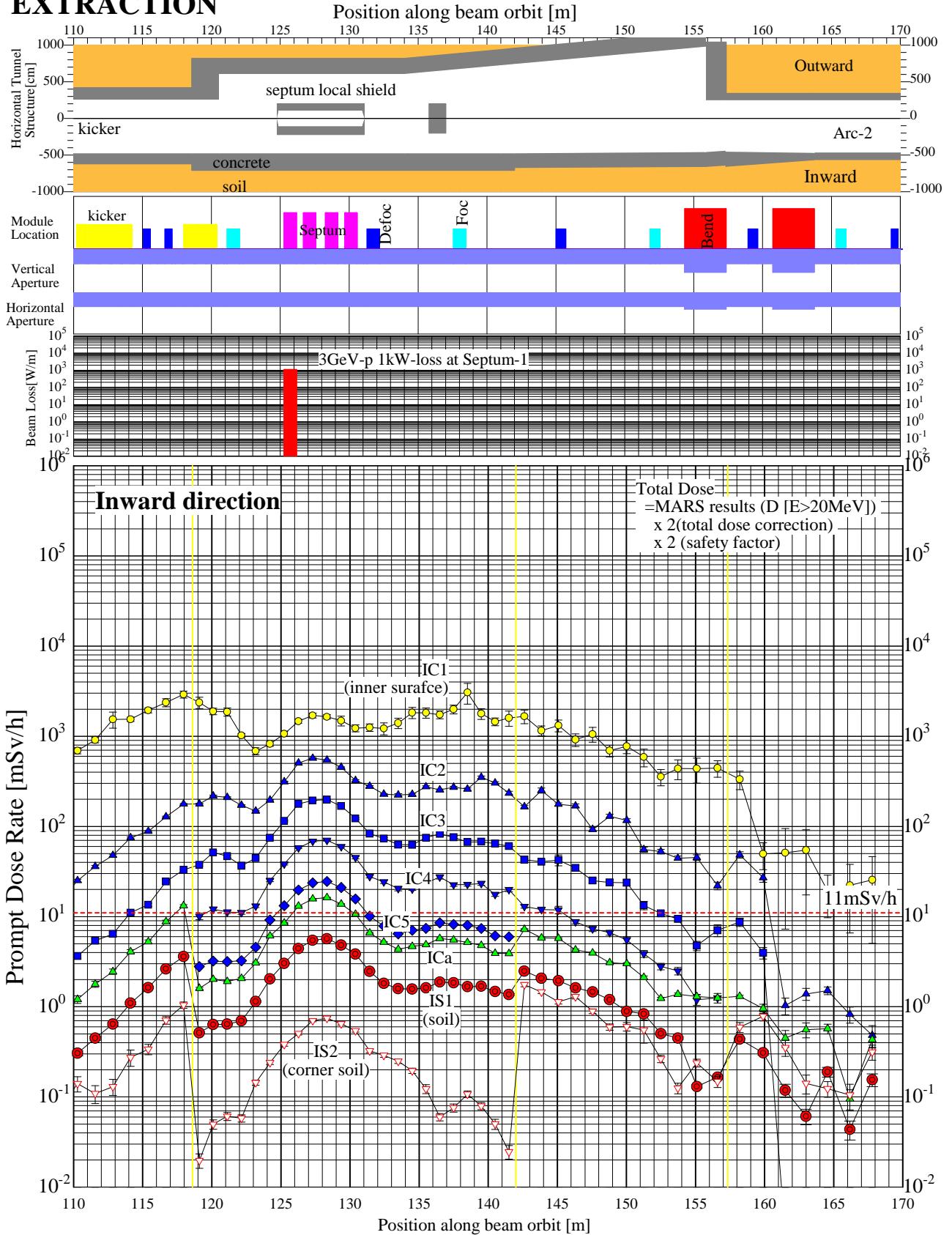


Figure 44: Calculated prompt dose rate distributions inside the shield of the ring inward direction around the extraction region. The numerical data are given in Tables 8. Vertical shield structure, machine module location, aperture structure and beam-loss distribution are also shown in the same region. Positions and sizes of the flux detectors(IC1~IS2) are shown in Fig. 17 (p.18) and tabulated in Table 3 (p.19).

EXTRACTION

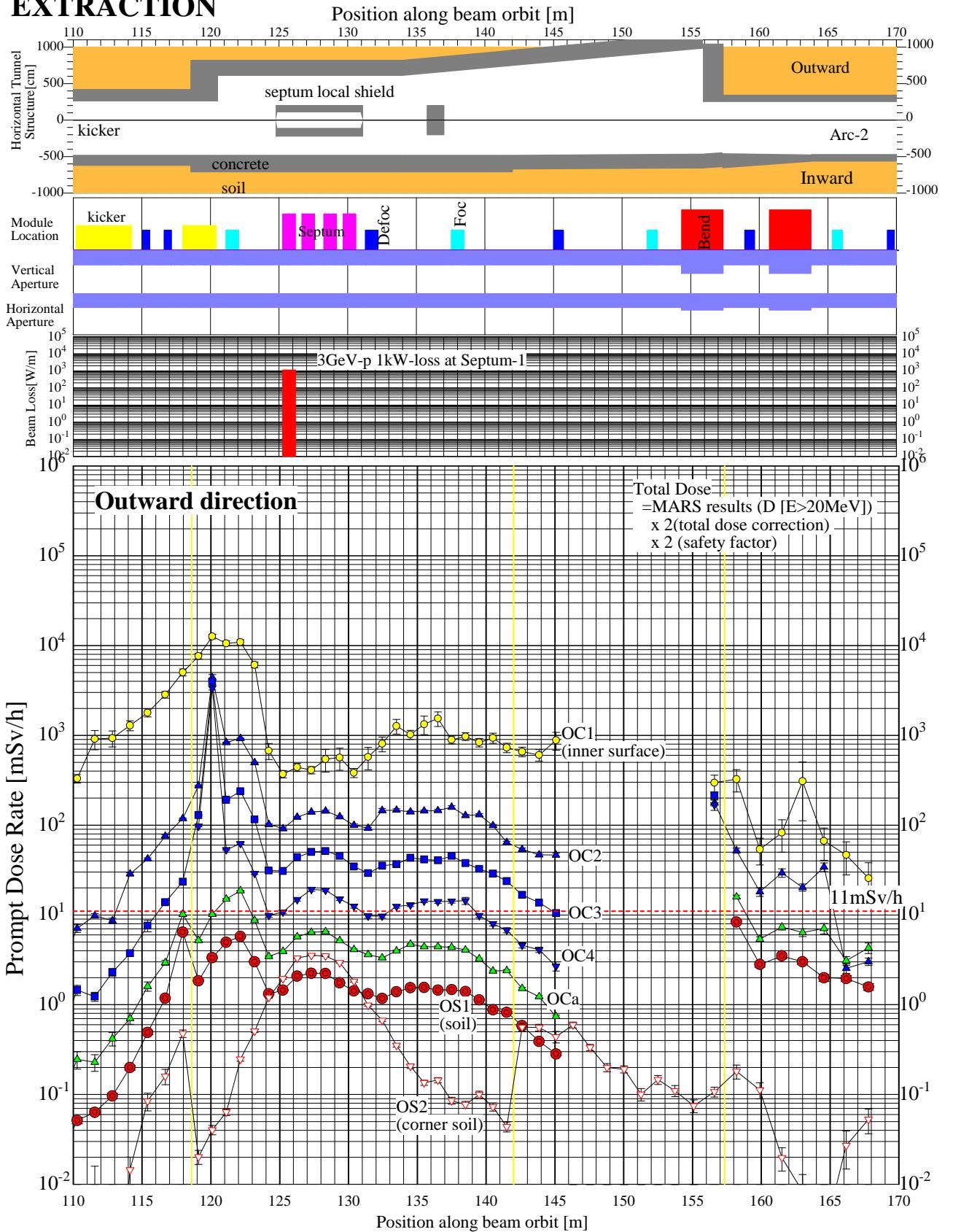


Figure 45: Calculated prompt dose rate distributions inside the shield of the ring outward direction around the extraction region. The numerical data are given in Tables 8. Vertical shield structure, machine module location, aperture structure and beam-loss distribution are also shown in the same region. Positions and sizes of the flux detectors(OC1~OS2) are shown in Fig. 17 (p.18) and tabulated in Table 3 (p.19).

Table 7: Prompt dose rates inside the concrete and soil shield in the region from the injection through collimator (1/9).

INJECTION Prompt dose UPWARD		Length (m)	Prompt-dose-rate(mSv/h) Error(%)							
Location-range (m)	Detector*		UC1	UCs	UC2	UC3				
-8.349	-7.349	1.000	9.74E+00	62.3	8.59E+01	79.1	3.20E+00	17.2	7.86E-01	32.7
-7.349	-6.299	1.050	3.29E+02	22.9	1.02E+02	74.7	6.26E+01	5.5	1.65E+01	9.1
-6.299	-5.249	1.050	8.24E+02	12.7	1.14E+02	58.9	1.81E+02	3.0	5.06E+01	5.2
-5.249	-4.199	1.050	1.10E+03	12.9	9.93E+01	45.8	2.15E+02	3.0	5.98E+01	5.2
-4.199	-3.150	1.050	1.44E+03	17.5	1.19E+02	42.1	3.46E+02	2.5	8.92E+01	4.2
-3.150	-2.100	1.050	1.40E+03	14.6	2.60E+02	55.8	2.76E+02	2.9	8.74E+01	4.6
-2.100	-1.050	1.050	1.71E+03	11.9	1.88E+02	29.8	3.03E+02	3.6	7.16E+01	4.9
-1.050	0.000	1.050	1.93E+03	10.8	2.86E+02	27.6	3.27E+02	2.6	6.28E+01	4.8
0.000	1.000	1.000	2.70E+03	11.2	8.07E+02	28.3	3.66E+02	2.8	8.07E+01	4.6
1.000	2.000	1.000	3.20E+03	15.1	7.23E+02	19.6	3.07E+02	3.2	7.64E+01	5.1
2.000	3.000	1.000	2.24E+03	18.1	8.62E+02	19.9	2.75E+02	3.5	4.81E+01	6.5
3.000	4.000	1.000	1.88E+03	19.0	8.37E+02	19.8	1.55E+02	4.6	4.45E+01	7.0
4.000	5.000	1.000	2.52E+03	18.4	8.65E+02	20.6	1.58E+02	4.5	3.23E+01	7.0
5.000	6.000	1.000	1.59E+03	25.0	9.66E+02	20.2	1.29E+02	5.2	2.30E+01	8.4
6.000	7.000	1.000	1.66E+03	26.1	1.51E+03	19.0	1.05E+02	5.2	2.31E+01	9.8
7.000	8.000	1.000	1.44E+03	19.8	8.62E+02	20.2	1.14E+02	5.3	2.06E+01	10.4
8.000	9.000	1.000	1.36E+03	27.0	1.09E+03	26.3	1.52E+02	4.8	2.33E+01	8.6
9.000	10.000	1.000	1.13E+03	26.3	1.25E+03	18.5	7.55E+01	7.1	3.14E+01	8.6
10.000	11.000	1.000	1.18E+03	25.7	1.29E+03	22.0	7.94E+01	4.9	1.36E+01	11.5
11.000	12.000	1.000	2.68E+03	23.4	1.39E+03	18.3	9.96E+01	4.4	2.97E+01	6.9
12.000	13.000	1.000	1.85E+03	14.2	2.06E+03	13.4	2.27E+02	2.8	5.67E+01	4.8
13.000	14.000	1.000	2.94E+03	15.1	3.02E+03	13.5	3.23E+02	2.4	8.35E+01	4.0
14.000	15.000	1.000	2.94E+03	8.8	3.45E+03	12.4	4.70E+02	2.2	1.30E+02	3.3
15.000	15.833	0.833	6.09E+03	11.6	3.41E+03	10.8	7.16E+02	1.8	1.70E+02	3.1
15.833	16.667	0.833	8.01E+03	6.2	4.60E+03	10.3	9.08E+02	1.6	2.16E+02	2.8
16.667	17.500	0.833	1.40E+04	6.5	5.11E+03	10.2	1.44E+03	1.3	3.15E+02	2.3
17.500	18.487	0.987	1.02E+04	6.7	5.60E+03	9.3	1.37E+03	1.3	3.66E+02	2.1
18.487	19.475	0.987	7.49E+03	6.9	4.86E+03	9.5	1.29E+03	1.4	3.34E+02	2.2
19.475	20.462	0.987	3.94E+03	7.2	5.82E+03	9.0	1.05E+03	1.5	3.09E+02	2.3
20.462	21.450	0.987	3.26E+03	9.3	4.91E+03	11.2	7.12E+02	1.8	2.15E+02	2.8
21.450	22.437	0.987	3.21E+03	9.9	4.72E+03	10.7	5.66E+02	2.0	1.58E+02	3.3
22.437	23.425	0.987	3.86E+03	9.4	3.79E+03	8.7	6.73E+02	1.9	1.83E+02	3.2
23.425	24.412	0.987	3.65E+03	9.2	4.45E+03	9.7	6.42E+02	2.0	1.58E+02	3.1
24.412	25.399	0.987	2.43E+03	9.9	3.99E+03	12.9	5.54E+02	2.1	1.67E+02	3.2
25.399	26.387	0.987	2.41E+03	15.9	3.29E+03	10.1	4.42E+02	2.5	1.29E+02	3.8
26.387	27.374	0.987	2.59E+03	16.8	3.09E+03	12.7	3.70E+02	2.7	1.08E+02	4.1
27.374	28.362	0.987	1.61E+03	15.3	3.11E+03	14.1	2.55E+02	3.3	8.08E+01	4.8
28.362	29.349	0.987	1.74E+03	16.3	1.71E+03	12.7	1.81E+02	3.9	5.07E+01	6.1
29.349	30.337	0.987	1.27E+03	16.1	1.77E+03	16.1	1.73E+02	3.5	4.17E+01	6.4
30.337	31.324	0.987	1.73E+03	17.6	1.97E+03	19.1	1.54E+02	4.1	3.98E+01	6.5
31.324	32.311	0.987	1.45E+03	18.5	1.85E+03	18.7	1.37E+02	4.4	2.74E+01	7.4
32.311	33.299	0.987	1.20E+03	22.0	1.26E+03	18.0	1.21E+02	4.4	3.42E+01	6.8
33.299	34.286	0.987	1.14E+03	16.6	9.38E+02	23.0	1.27E+02	4.3	3.69E+01	7.3
34.286	35.274	0.987	1.75E+03	18.0	8.54E+02	27.4	1.47E+02	3.9	2.37E+01	7.1
35.274	36.261	0.987	1.15E+03	20.4	9.11E+02	20.4	1.76E+02	4.0	4.36E+01	6.7
36.261	37.249	0.987	1.73E+03	16.3	7.29E+02	22.9	1.64E+02	4.1	4.04E+01	6.4
37.249	38.236	0.987	1.54E+03	21.1	6.57E+02	21.4	1.49E+02	4.3	4.05E+01	7.3
38.236	39.736	1.500	1.76E+03	18.5	1.07E+03	28.6	9.69E+01	4.0	2.83E+01	6.4
39.736	41.236	1.500	1.53E+03	24.1	9.53E+02	32.5	1.08E+02	4.8	2.14E+01	7.3
41.236	42.369	1.133	1.03E+03	26.6	5.06E+02	25.5	1.19E+02	5.8	2.61E+01	9.0
42.369	43.503	1.133	3.65E+02	29.7	6.08E+02	26.1	3.31E+01	8.4	1.89E+01	10.4
43.503	44.636	1.133	7.61E+02	29.4	3.68E+02	30.8	4.43E+01	8.3	6.40E+00	17.5
44.636	46.136	1.500	1.88E+02	44.2	4.08E+02	47.8	5.21E+01	6.9	7.88E+00	11.2
46.136	47.636	1.500	1.57E+02	40.2	2.69E+02	35.6	1.62E+01	17.3	2.86E+00	21.9
47.636	48.818	1.182	1.14E+02	57.8	3.44E+02	71.3	3.88E+00	22.1	3.85E+00	25.9
48.818	50.000	1.182	2.49E+02	67.9	2.21E+02	51.6	1.36E+01	14.6	4.16E+00	18.3
50.000	51.175	1.175	1.97E+02	52.4	3.56E+02	46.6	8.56E+00	15.5		
51.175	52.350	1.175	3.34E+02	48.6	1.11E+02	70.2	1.70E+01	18.1		
52.350	53.525	1.175	6.45E+01	44.5	8.98E+01	66.3	2.42E+01	9.7		
53.525	54.700	1.175	1.82E+02	65.7	3.47E+02	62.6	1.80E+01	10.1		
54.700	55.874	1.175	1.58E+02	62.6	1.95E+02	61.7	3.46E+00	16.6		
55.874	57.049	1.175	3.43E+02	61.1	1.70E+01	70.9	3.94E+00	18.1		
57.049	58.224	1.175	1.19E+02	56.4	1.38E+02	66.2	2.14E+00	36.2		
58.224	59.399	1.175	6.33E+01	44.4	2.86E+01	87.2	1.25E+01	12.0		
59.399	60.574	1.175	1.21E+02	52.3	1.70E+02	91.6	1.11E+01	10.4		
60.574	62.074	1.500	6.88E+01	70.0	2.44E+02	99.5	2.96E-01	48.0		
62.074	63.574	1.500	5.19E+01	43.6	1.24E+00	68.4	1.08E+01	12.4		
63.574	64.707	1.133	1.77E+02	77.5	1.13E+02	88.0	9.96E+00	12.5		
64.707	65.841	1.133	1.82E+02	74.4	1.18E+01	63.0	1.72E+00	46.9		
65.841	66.974	1.133	2.16E+01	71.7	1.69E-01	100.0	4.93E-01	75.2		
66.974	68.474	1.500	6.37E-01	71.8			4.14E-01	52.8		
68.474	69.974	1.500	3.69E+01	52.7	3.94E+00	100.0	3.11E+00	18.4		
69.974	71.341	1.367	1.76E+02	68.7						

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 7 continued (2/9).

INJECTION Prompt dose UPWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)							
		Detector*		UC4		UC5		UCa	
		UC4	UC5	UC4	UC5	UCa	US1	UCa	US1
-8.349	-7.349	1.000	6.45E-01	34.6	3.75E-01	28.1	7.50E-04	10.8	5.29E-04
-7.349	-6.299	1.050	5.19E+00	13.3	1.01E+00	5.1	4.73E-01	7.9	1.80E-01
-6.299	-5.249	1.050	1.18E+01	9.1	1.83E+00	3.5	8.59E-01	4.9	3.32E-01
-5.249	-4.199	1.050	1.31E+01	8.4	2.27E+00	3.3	1.11E+00	4.6	4.18E-01
-4.199	-3.150	1.050	1.98E+01	7.1	3.78E+00	2.6	1.72E+00	4.0	6.07E-01
-3.150	-2.100	1.050	2.72E+01	6.4	4.83E+00	2.4	2.52E+00	3.3	8.15E-01
-2.100	-1.050	1.050	1.95E+01	8.0	3.85E+00	2.7	2.04E+00	4.2	6.58E-01
-1.050	0.000	1.050	1.71E+01	7.9	2.46E+00	3.4	1.16E+00	5.1	4.47E-01
0.000	1.000	1.000	1.92E+01	7.7	2.58E+00	3.1	1.18E+00	4.7	4.17E-01
1.000	2.000	1.000	1.83E+01	8.4	3.50E+00	3.0	1.59E+00	4.1	4.79E-01
2.000	3.000	1.000	1.08E+01	11.5	1.91E+00	3.9	9.58E-01	5.4	3.92E-01
3.000	4.000	1.000	1.14E+01	11.4	1.44E+00	4.3	6.74E-01	5.9	3.05E-01
4.000	5.000	1.000	9.98E+00	11.4	1.37E+00	4.2	6.23E-01	6.0	2.42E-01
5.000	6.000	1.000	6.09E+00	16.3	1.06E+00	5.4	5.32E-01	6.8	2.34E-01
6.000	7.000	1.000	6.16E+00	15.2	5.86E-01	7.4	2.17E-01	10.2	1.05E-01
7.000	8.000	1.000	3.40E+00	19.0	8.26E-01	6.3	3.47E-01	8.6	1.29E-01
8.000	9.000	1.000	5.30E+00	14.3	7.89E-01	5.8	3.47E-01	8.4	1.23E-01
9.000	10.000	1.000	7.10E+00	12.7	1.24E+00	5.3	5.92E-01	7.0	1.61E-01
10.000	11.000	1.000	3.80E+00	15.7	6.10E-01	6.4	6.76E-02	20.9	2.43E-02
11.000	12.000	1.000	6.78E+00	12.6	9.80E-01	5.1	9.67E-02	16.8	3.01E-02
12.000	13.000	1.000	1.60E+01	8.4	2.60E+00	3.1	1.64E-01	11.8	6.68E-02
13.000	14.000	1.000	2.41E+01	6.5	4.52E+00	2.4	3.57E-01	8.4	1.19E-01
14.000	15.000	1.000	3.50E+01	5.5	6.54E+00	2.0	5.58E-01	7.2	1.69E-01
15.000	15.833	0.833	4.58E+01	5.1	7.10E+00	2.0	5.20E-01	7.4	1.93E-01
15.833	16.667	0.833	5.30E+01	4.8	8.49E+00	1.9	5.68E-01	7.6	2.17E-01
16.667	17.500	0.833	7.88E+01	3.9	1.36E+01	1.5	9.14E-01	5.9	3.12E-01
17.500	18.487	0.987	9.52E+01	3.7	1.50E+01	1.3	1.06E+00	5.0	3.58E-01
18.487	19.475	0.987	9.16E+01	3.8	1.57E+01	1.3	1.14E+00	4.7	3.84E-01
19.475	20.462	0.987	9.35E+01	3.6	1.62E+01	1.3	1.27E+00	4.7	4.03E-01
20.462	21.450	0.987	6.58E+01	4.5	1.21E+01	1.5	9.35E-01	5.3	3.08E-01
21.450	22.437	0.987	5.11E+01	5.0	8.99E+00	1.8	7.94E-01	6.0	3.13E-01
22.437	23.425	0.987	5.52E+01	4.9	9.16E+00	1.7	7.11E-01	6.1	2.63E-01
23.425	24.412	0.987	4.45E+01	5.0	8.73E+00	1.8	6.49E-01	6.4	2.16E-01
24.412	25.399	0.987	4.19E+01	5.2	7.46E+00	1.9	6.15E-01	6.7	1.96E-01
25.399	26.387	0.987	3.85E+01	5.7	6.46E+00	2.1	4.44E-01	7.7	1.69E-01
26.387	27.374	0.987	3.00E+01	6.1	5.28E+00	2.3	3.65E-01	8.5	1.50E-01
27.374	28.362	0.987	2.92E+01	7.1	4.93E+00	2.4	3.53E-01	9.5	1.20E-01
28.362	29.349	0.987	1.46E+01	8.7	3.21E+00	3.0	3.01E-01	9.3	8.16E-02
29.349	30.337	0.987	1.01E+01	10.9	2.04E+00	3.9	2.18E-01	12.6	8.11E-02
30.337	31.324	0.987	1.19E+01	9.9	2.39E+00	3.6	1.49E-01	13.9	5.79E-02
31.324	32.311	0.987	8.35E+00	10.6	1.83E+00	4.1	1.15E-01	17.3	3.62E-02
32.311	33.299	0.987	9.58E+00	11.0	1.30E+00	4.6	6.39E-02	17.3	3.25E-02
33.299	34.286	0.987	7.60E+00	12.2	1.41E+00	4.3	1.25E-01	16.3	3.88E-02
34.286	35.274	0.987	8.44E+00	12.0	1.21E+00	4.9	8.92E-02	17.4	3.14E-02
35.274	36.261	0.987	1.14E+01	11.5	1.49E+00	4.2	8.61E-02	16.6	4.09E-02
36.261	37.249	0.987	1.20E+01	10.9	1.51E+00	4.0	6.72E-02	17.9	2.67E-02
37.249	38.236	0.987	9.81E+00	10.5	1.65E+00	4.2	1.24E-01	15.5	3.51E-02
38.236	39.736	1.500					6.78E+00	9.8	2.19E+00
39.736	41.236	1.500					4.40E+00	12.1	1.50E+00
41.236	42.369	1.133					5.80E+00	13.1	1.30E+00
42.369	43.503	1.133					3.35E+00	15.1	8.59E-01
43.503	44.636	1.133					8.63E-01	26.4	5.76E-01
44.636	46.136	1.500					1.03E+00	25.4	2.96E-01
46.136	47.636	1.500					8.49E-01	32.9	1.54E-01
47.636	48.818	1.182					2.33E-01	44.9	7.79E-02
48.818	50.000	1.182					1.04E+00	26.2	3.58E-01
50.000	51.175	1.175					1.76E+00	18.1	1.13E+00
51.175	52.350	1.175					2.83E+00	17.1	7.21E-01
52.350	53.525	1.175					2.19E+00	19.1	8.79E-01
53.525	54.700	1.175					4.41E+00	14.8	9.76E-01
54.700	55.874	1.175					1.19E+00	27.6	6.82E-01
55.874	57.049	1.175					1.04E+00	26.4	4.25E-01
57.049	58.224	1.175					2.79E-01	49.9	1.13E-02
58.224	59.399	1.175					1.51E+00	21.3	3.10E-01
59.399	60.574	1.175					4.10E+00	15.5	1.20E+00
60.574	62.074	1.500					9.08E-01	22.6	3.13E-01
62.074	63.574	1.500					8.42E-01	29.7	4.12E-01
63.574	64.707	1.133					1.81E+00	22.2	6.47E-01
64.707	65.841	1.133					8.99E-01	29.1	1.68E-01
65.841	66.974	1.133					5.40E-02	99.2	1.69E-01
66.974	68.474	1.500					1.61E+00	19.3	3.63E-01
68.474	69.974	1.500					2.99E-01	42.6	1.51E-01
69.974	71.341	1.367					7.07E-02	70.8	9.04E-02

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 7 continued (3/9).

INJECTION Prompt dose UPWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)					
		Detector* US2		US3		US4	
-8.349	-7.349	1.000	9.31E-05	19.7	8.23E-05	18.1	1.42E-05 48.3
-7.349	-6.299	1.050	2.77E-03	4.0	2.78E-04	10.8	4.18E-05 23.1
-6.299	-5.249	1.050	5.62E-03	2.7	3.42E-04	8.8	2.92E-05 23.1
-5.249	-4.199	1.050	7.87E-03	2.4	5.59E-04	7.2	5.09E-05 17.7
-4.199	-3.150	1.050	9.24E-03	2.1	7.40E-04	5.6	7.56E-05 14.9
-3.150	-2.100	1.050	1.45E-02	1.7	9.54E-04	5.1	9.32E-05 14.9
-2.100	-1.050	1.050	1.51E-02	1.7	1.14E-03	4.9	1.27E-04 12.0
-1.050	0.000	1.050	1.03E-02	2.0	1.02E-03	5.6	9.07E-05 14.0
0.000	1.000	1.000	7.04E-03	2.4	7.08E-04	6.5	9.76E-05 15.6
1.000	2.000	1.000	7.42E-03	2.3	5.51E-04	7.0	7.53E-05 18.8
2.000	3.000	1.000	8.94E-03	2.2	6.58E-04	6.7	6.65E-05 17.7
3.000	4.000	1.000	6.86E-03	2.4	6.17E-04	7.2	5.32E-05 19.1
4.000	5.000	1.000	5.95E-03	2.7	5.57E-04	7.1	6.94E-05 18.5
5.000	6.000	1.000	6.89E-03	2.6	5.18E-04	7.5	6.13E-05 16.9
6.000	7.000	1.000	3.91E-03	3.4	4.43E-04	8.7	4.43E-05 23.2
7.000	8.000	1.000	3.17E-03	3.8	2.66E-04	10.6	2.27E-05 24.1
8.000	9.000	1.000	2.84E-03	4.2	2.35E-04	10.9	3.21E-05 27.7
9.000	10.000	1.000	3.47E-03	3.5	2.68E-04	10.6	2.97E-05 25.0
10.000	11.000	1.000	3.07E-03	3.9	2.58E-04	10.5	6.08E-05 23.8
11.000	12.000	1.000	4.68E-03	3.2	5.46E-04	7.8	5.85E-05 19.9
12.000	13.000	1.000	6.38E-03	2.5	6.08E-04	6.8	8.69E-05 17.9
13.000	14.000	1.000	9.55E-03	2.1	8.26E-04	6.0	8.30E-05 14.2
14.000	15.000	1.000	1.19E-02	1.8	9.72E-04	5.2	1.18E-04 13.6
15.000	15.833	0.833	1.49E-02	1.8	1.01E-03	5.7	8.71E-05 14.6
15.833	16.667	0.833	1.53E-02	1.8	1.12E-03	5.3	1.16E-04 13.8
16.667	17.500	0.833	2.03E-02	1.5	1.28E-03	4.9	1.22E-04 13.5
17.500	18.487	0.987	2.54E-02	1.2	1.67E-03	4.1	1.70E-04 11.0
18.487	19.475	0.987	2.83E-02	1.2	1.96E-03	3.8	1.99E-04 10.6
19.475	20.462	0.987	3.00E-02	1.2	2.00E-03	3.7	1.98E-04 10.3
20.462	21.450	0.987	2.45E-02	1.3	1.84E-03	4.0	1.97E-04 10.0
21.450	22.437	0.987	2.35E-02	1.3	1.63E-03	4.1	1.92E-04 10.8
22.437	23.425	0.987	1.97E-02	1.4	1.46E-03	4.3	1.69E-04 10.1
23.425	24.412	0.987	1.72E-02	1.5	1.27E-03	4.6	1.09E-04 12.5
24.412	25.399	0.987	1.53E-02	1.7	1.23E-03	4.8	1.29E-04 12.5
25.399	26.387	0.987	1.46E-02	1.7	1.07E-03	5.2	1.07E-04 13.0
26.387	27.374	0.987	1.08E-02	2.1	8.65E-04	5.8	8.77E-05 15.9
27.374	28.362	0.987	9.74E-03	2.2	7.47E-04	6.1	1.16E-04 14.1
28.362	29.349	0.987	8.17E-03	2.4	6.63E-04	6.7	5.85E-05 17.6
29.349	30.337	0.987	7.14E-03	2.5	5.37E-04	7.5	5.02E-05 19.2
30.337	31.324	0.987	5.15E-03	3.1	4.45E-04	8.2	5.83E-05 18.9
31.324	32.311	0.987	2.58E-03	4.2	3.01E-04	10.3	3.54E-05 27.1
32.311	33.299	0.987	2.48E-03	4.4	2.41E-04	10.9	1.99E-05 27.4
33.299	34.286	0.987	2.82E-03	4.0	2.49E-04	11.1	1.92E-05 31.2
34.286	35.274	0.987	2.30E-03	4.2	1.38E-04	13.3	1.92E-05 32.5
35.274	36.261	0.987	2.24E-03	4.1	1.46E-04	13.8	2.58E-05 28.1
36.261	37.249	0.987	1.97E-03	4.6	1.42E-04	13.8	1.25E-05 33.4
37.249	38.236	0.987	3.55E-03	3.2	2.33E-04	11.0	3.21E-05 25.1
38.236	39.736	1.500	4.53E-03	2.3	3.06E-04	7.6	2.58E-05 23.8
39.736	41.236	1.500	6.31E-03	2.1	4.08E-04	6.8	3.67E-05 18.8
41.236	42.369	1.133	9.20E-03	2.2	6.46E-04	6.5	7.02E-05 17.0
42.369	43.503	1.133	6.75E-03	2.5	6.57E-04	6.9	7.13E-05 16.0
43.503	44.636	1.133	3.00E-03	3.6	3.19E-04	9.5	5.10E-05 19.6
44.636	46.136	1.500	1.66E-03	4.2	1.05E-04	14.3	1.21E-05 32.7
46.136	47.636	1.500	8.15E-04	6.4	6.00E-05	18.1	4.63E-06 40.7
47.636	48.818	1.182	6.85E-04	7.3	5.60E-05	23.5	9.39E-06 43.9
48.818	50.000	1.182	7.52E-04	6.6	7.15E-05	16.6	5.30E-06 48.1
50.000	51.175	1.175	1.77E-03	4.4	1.02E-04	14.5	3.90E-06 51.1
51.175	52.350	1.175	1.98E-03	4.6	1.61E-04	12.1	2.23E-05 30.1
52.350	53.525	1.175	2.16E-03	4.3	2.51E-04	10.7	3.18E-05 24.8
53.525	54.700	1.175	1.80E-03	5.0	2.45E-04	12.5	7.05E-06 40.9
54.700	55.874	1.175	9.37E-04	6.1	9.76E-05	15.5	1.53E-05 34.4
55.874	57.049	1.175	1.32E-03	5.0	5.89E-05	17.7	1.36E-06 78.7
57.049	58.224	1.175	2.26E-04	12.3	2.36E-05	32.5	2.46E-06 61.4
58.224	59.399	1.175	2.77E-04	10.1	2.68E-05	29.0	2.50E-06 99.7
59.399	60.574	1.175	9.22E-04	5.7	4.16E-05	24.3	2.27E-06 63.9
60.574	62.074	1.500	6.44E-04	6.3	4.58E-05	18.0	5.80E-06 44.5
62.074	63.574	1.500	1.54E-04	13.8	7.11E-06	50.1	5.69E-07 100.0
63.574	64.707	1.133	1.09E-04	17.8	6.88E-06	52.3	2.33E-06 100.0
64.707	65.841	1.133	4.11E-05	27.0	7.47E-06	45.1	2.65E-06 70.1
65.841	66.974	1.133	2.33E-04	11.7	2.30E-05	41.1	5.51E-06 52.2
66.974	68.474	1.500	2.79E-04	10.0	1.46E-05	43.5	
68.474	69.974	1.500	1.62E-04	11.4	8.73E-06	38.8	
69.974	71.341	1.367	1.43E-04	15.8	5.89E-06	46.9	1.90E-06 100.0

* Detector name means

Direction - "U"; upward, "D"; downward, "I"; inward and "O"; outward.

Shield - "C":concrete and "S":soil.

Table. 7 continued (4/9).

INJECTION Prompt dose DOWNWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)										
		Detector*		DCs		DC2		DC3				
	DC1		DCs		DC2		DC3		DC4			
-8.349	-7.349	1.000	3.35E+03	8.9	2.66E+01	100.0	2.19E+02	3.0	6.45E+01	4.7	3.34E+01	6.5
-7.349	-6.299	1.050	2.07E+04	2.9	1.39E+02	64.5	2.75E+03	7.4	4.79E+02	12.8	1.09E+02	25.5
-6.299	-5.249	1.050	1.21E+05	1.5	1.13E+02	43.0	1.25E+04	3.1	2.27E+03	6.4	5.65E+02	10.9
-5.249	-4.199	1.050	1.70E+05	1.5	3.07E+02	32.8	2.34E+04	2.6	4.85E+03	4.7	1.01E+03	8.1
-4.199	-3.150	1.050	1.78E+04	4.7	8.76E+01	59.1	1.15E+04	4.3	3.59E+03	5.8	8.64E+02	9.7
-3.150	-2.100	1.050	1.16E+04	8.9	3.84E+02	38.6	1.43E+03	1.4	7.57E+02	1.8	3.39E+02	2.1
-2.100	-1.050	1.050	1.30E+04	6.7	4.36E+02	28.8	1.14E+03	1.6	2.25E+02	2.7	7.01E+01	4.9
-1.050	0.000	1.050	1.17E+04	7.8	7.08E+02	29.3	7.73E+02	2.1	1.57E+02	3.4	3.83E+01	5.4
0.000	1.000	1.000	7.35E+03	10.2	7.29E+02	23.2	5.46E+02	2.7	1.04E+02	4.7	2.39E+01	7.4
1.000	2.000	1.000	5.01E+03	12.4	8.15E+02	29.3	3.24E+02	2.9	7.79E+01	5.4	2.13E+01	8.9
2.000	3.000	1.000	4.23E+03	14.1	9.52E+02	25.8	2.69E+02	3.6	5.58E+01	5.8	1.45E+01	9.8
3.000	4.000	1.000	3.29E+03	23.6	8.86E+02	20.6	1.96E+02	3.8	4.24E+01	6.6	1.13E+01	11.6
4.000	5.000	1.000	2.98E+03	22.1	1.65E+03	35.4	1.39E+02	4.6	3.93E+01	6.9	9.42E+00	10.2
5.000	6.000	1.000	2.15E+03	22.3	9.46E+02	28.2	1.11E+02	6.2	2.20E+01	9.1	8.29E+00	13.9
6.000	7.000	1.000	4.11E+03	19.9	1.16E+03	32.6	7.06E+01	5.0	1.49E+01	9.9	4.61E+00	14.7
7.000	8.000	1.000	3.55E+03	17.0	5.88E+02	44.5	9.10E+01	4.8	1.51E+01	9.4	4.69E+00	15.1
8.000	9.000	1.000	4.87E+03	17.0	1.16E+03	33.1	1.32E+02	4.5	2.48E+01	7.9	4.68E+00	15.4
9.000	10.000	1.000	4.46E+03	17.4	9.46E+02	24.3	8.42E+01	5.7	2.30E+01	8.0	6.46E+00	13.1
10.000	11.000	1.000	3.18E+03	20.3	8.78E+02	25.9	1.65E+02	4.2	3.32E+01	6.7	7.59E+00	11.5
11.000	12.000	1.000	3.96E+03	10.4	1.76E+03	23.1	2.65E+02	2.7	5.84E+01	5.0	2.04E+01	7.8
12.000	13.000	1.000	1.55E+04	5.1	2.09E+03	12.9	1.75E+03	1.0	4.57E+02	1.9	9.21E+01	3.3
13.000	14.000	1.000	9.71E+04	1.6	4.62E+03	10.7	1.17E+04	3.4	2.20E+03	6.5	4.72E+02	11.6
14.000	15.000	1.000	5.57E+04	3.6	5.58E+03	8.8	8.58E+03	4.3	2.14E+03	8.0	6.07E+02	12.2
15.000	15.833	0.833	8.42E+04	2.8	6.54E+03	28.9	7.22E+03	5.3	1.62E+03	10.0	5.33E+02	14.1
15.833	16.667	0.833	1.01E+05	3.0	4.97E+03	12.4	8.10E+03	5.0	1.93E+03	9.0	4.37E+02	15.2
16.667	17.500	0.833	2.03E+05	2.3	4.78E+03	12.8	1.07E+04	4.5	1.89E+03	8.2	3.99E+02	15.0
17.500	18.487	0.987	4.67E+05	1.6	5.72E+03	10.0	1.59E+04	3.3	3.03E+03	6.0	7.52E+02	11.2
18.487	19.475	0.987	7.62E+05	1.3	5.03E+03	9.8	2.32E+04	2.8	4.49E+03	5.3	1.13E+03	9.5
19.475	20.462	0.987	5.51E+05	1.6	6.63E+03	8.5	3.03E+04	2.5	5.95E+03	4.4	1.31E+03	7.5
20.462	21.450	0.987	1.65E+05	2.7	6.38E+03	10.1	1.70E+04	3.9	4.30E+03	5.9	1.12E+03	10.1
21.450	22.437	0.987	8.38E+04	2.9	5.82E+03	9.5	9.74E+03	5.2	1.97E+03	8.0	5.22E+02	12.8
22.437	23.425	0.987	5.05E+04	3.5	4.91E+03	10.5	5.90E+03	6.0	1.62E+03	10.7	3.96E+02	19.4
23.425	24.412	0.987	6.76E+04	3.2	4.51E+03	11.2	6.88E+03	5.6	1.66E+03	9.1	4.04E+02	16.6
24.412	25.399	0.987	4.25E+04	3.6	5.06E+03	10.5	6.83E+03	6.2	1.37E+03	8.7	3.93E+02	16.7
25.399	26.387	0.987	3.10E+04	3.8	4.49E+03	12.6	3.40E+03	7.4	7.92E+02	12.5	1.82E+02	20.5
26.387	27.374	0.987	3.58E+04	3.5	4.21E+03	14.0	4.61E+03	5.1	8.53E+02	7.9	1.63E+02	16.4
27.374	28.362	0.987	1.37E+04	5.5	3.50E+03	13.0	2.92E+03	1.0	6.89E+02	1.6	1.61E+02	2.7
28.362	29.349	0.987	1.56E+04	6.7	3.36E+03	14.9	1.32E+03	1.5	3.67E+02	3.4	1.01E+02	3.7
29.349	30.337	0.987	1.39E+04	8.1	2.56E+03	16.9	9.45E+02	1.8	1.91E+02	3.1	5.22E+01	5.0
30.337	31.324	0.987	1.52E+04	7.0	1.58E+03	18.8	9.94E+02	1.8	2.12E+02	2.9	4.97E+01	5.0
31.324	32.311	0.987	1.71E+04	6.5	1.28E+03	19.9	1.61E+03	1.1	3.32E+02	2.2	7.54E+01	4.0
32.311	33.299	0.987	6.97E+03	7.7	1.03E+03	25.2	1.06E+03	1.6	2.46E+02	2.7	6.69E+01	4.5
33.299	34.286	0.987	4.96E+03	9.2	1.11E+03	22.3	8.11E+02	1.8	1.66E+02	3.2	4.11E+01	5.1
34.286	35.274	0.987	5.23E+03	11.3	8.92E+02	23.8	5.24E+02	2.3	1.11E+02	4.1	2.63E+01	6.7
35.274	36.261	0.987	9.01E+03	9.6	9.64E+02	24.2	3.97E+02	2.5	8.56E+01	4.3	2.18E+01	7.9
36.261	37.249	0.987	6.44E+03	13.4	5.46E+02	34.5	4.17E+02	2.8	8.36E+01	4.6	1.98E+01	8.1
37.249	38.236	0.987	2.51E+03	16.1	1.06E+03	30.7	1.73E+02	3.8	5.35E+01	6.7	1.10E+01	10.0
38.236	39.736	1.500	2.18E+03	18.7	7.86E+02	38.2	9.60E+01	4.0				
39.736	41.236	1.500	9.13E+02	34.3	7.30E+02	31.8	2.95E+01	7.4				
41.236	42.369	1.133	4.47E+02	53.8	3.78E+02	37.3	3.59E+01	8.6				
42.369	43.503	1.133	4.45E+02	41.5	6.18E+02	32.5	7.97E+00	16.5				
43.503	44.636	1.133	8.38E+01	54.5	3.68E+02	44.1	1.08E+01	13.2				
44.636	46.136	1.500	3.58E+02	48.5	2.42E+02	49.1	1.64E+01	10.3				
46.136	47.636	1.500	2.78E+01	79.3	8.28E+01	58.2	2.16E+00	30.1				
47.636	48.818	1.182	5.85E+01	48.4	2.21E+02	59.9	9.00E+00	15.8				
48.818	50.000	1.182	3.97E+02	58.6	7.31E+01	60.3	6.01E+00	15.5				
50.000	51.175	1.175	1.59E+02	68.5	5.03E+01	65.4	4.90E+00	17.2				
51.175	52.350	1.175	2.26E+02	46.6	3.05E+02	41.5	5.21E+01	8.0				
52.350	53.525	1.175	7.77E+02	37.7	2.46E+01	73.2	1.82E+01	9.9				
53.525	54.700	1.175	2.86E+02	45.5	1.65E+02	71.0	6.24E+00	14.9				
54.700	55.874	1.175	5.35E+02	38.5	9.66E-01	70.8	5.51E+00	17.7				
55.874	57.049	1.175	7.63E+01	84.4	1.03E+01	72.8	1.26E+01	13.9				
57.049	58.224	1.175	1.81E+02	93.3	1.86E+01	95.0	4.72E+00	21.7				
58.224	59.399	1.175	3.14E+02	78.7	5.72E+01	80.0	4.56E-01	55.6				
59.399	60.574	1.175	1.98E+02	45.0	1.09E+02	58.5	3.17E+01	10.6				
60.574	62.074	1.500	4.23E+02	38.4			2.49E+01	6.7				
62.074	63.574	1.500	2.14E+02	55.4	6.39E+00	93.5	7.83E+00	16.7				
63.574	64.707	1.133	1.27E+02	32.6	1.39E+02	83.9	1.59E+01	9.0				
64.707	65.841	1.133	2.19E+02	37.4	3.04E+01	80.3	1.77E+01	9.5				
65.841	66.974	1.133	2.00E+01	69.5			8.94E+00	15.5				
66.974	68.474	1.500	2.23E+02	58.9	4.05E+01	78.8	6.39E-01	47.5				
68.474	69.974	1.500	9.58E+01	99.6	2.56E+00	100.0	7.47E+00	17.5				
69.974	71.341	1.367	5.09E+01	60.6	1.79E+01	97.6	9.68E+00	12.9				

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 7 continued (5/9).

INJECTION Prompt dose DOWNWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)								
		Detector* DCa	DCb	DCc	DS1					
-8.349	-7.349	1.000	4.68E+00	2.4	1.08E+01	1.5	7.10E-01	6.1	2.52E-01	5.9
-7.349	-6.299	1.050	3.15E+01	5.2	2.14E+01	5.8	1.48E+00	4.0	4.69E-01	4.1
-6.299	-5.249	1.050	1.32E+02	2.4	3.70E+01	4.3	2.04E+00	3.3	8.41E-01	3.2
-5.249	-4.199	1.050	2.76E+02	1.8	5.43E+01	3.7	4.35E+00	2.3	1.60E+00	2.3
-4.199	-3.150	1.050	2.71E+02	1.9	5.50E+01	3.7	5.08E+00	2.2	1.69E+00	2.3
-3.150	-2.100	1.050	1.23E+02	3.0	4.79E+01	4.2	3.95E+00	2.6	1.44E+00	2.4
-2.100	-1.050	1.050	3.02E+01	6.2	3.73E+01	5.1	3.04E+00	3.0	1.22E+00	2.7
-1.050	0.000	1.050	1.19E+01	7.1	2.15E+01	5.7	2.40E+00	3.6	7.82E-01	3.4
0.000	1.000	1.000	6.66E+00	2.1	1.27E+01	1.6	1.05E+00	5.2	4.14E-01	4.9
1.000	2.000	1.000	5.64E+00	2.2	5.74E+00	2.4	4.81E-01	8.1	2.00E-01	6.7
2.000	3.000	1.000	3.87E+00	2.6	4.23E+00	2.7	2.58E-01	10.7	1.06E-01	9.1
3.000	4.000	1.000	2.67E+00	3.8	2.52E+00	3.4	1.84E-01	12.6	7.60E-02	10.8
4.000	5.000	1.000	3.32E+00	3.0	2.23E+00	3.7	1.15E-01	14.1	4.35E-02	14.2
5.000	6.000	1.000	3.05E+00	3.3	1.83E+00	4.3	1.13E-01	15.6	3.94E-02	15.4
6.000	7.000	1.000	1.67E+00	4.1	1.27E+00	4.6	1.01E-01	16.2	3.61E-02	15.9
7.000	8.000	1.000	1.28E+00	4.8	1.47E+00	4.7	7.07E-02	22.8	2.92E-02	16.8
8.000	9.000	1.000	1.64E+00	3.9	1.75E+00	4.1	9.03E-02	14.9	2.93E-02	16.7
9.000	10.000	1.000	2.17E+00	3.5	2.34E+00	3.5	1.75E-01	11.9	5.02E-02	13.2
10.000	11.000	1.000	2.75E+00	3.0	4.44E+00	2.8	2.71E-01	9.6	9.58E-02	9.2
11.000	12.000	1.000	6.37E+00	2.0	9.41E+00	1.7	6.35E-01	6.3	2.11E-01	6.3
12.000	13.000	1.000	2.26E+01	1.0	1.75E+01	1.1	1.49E+00	3.9	6.09E-01	3.7
13.000	14.000	1.000	1.12E+02	2.6	3.07E+01	5.0	2.92E+00	2.9	9.37E-01	3.0
14.000	15.000	1.000	1.18E+02	2.9	2.90E+01	4.9	2.32E+00	3.2	7.47E-01	3.3
15.000	15.833	0.833	1.47E+02	2.9	3.06E+01	5.3	2.59E+00	3.5	9.87E-01	3.2
15.833	16.667	0.833	1.38E+02	3.0	4.49E+01	4.6	2.74E+00	3.3	1.10E+00	3.1
16.667	17.500	0.833	1.58E+02	2.7	5.82E+01	4.2	5.12E+00	2.5	1.79E+00	2.4
17.500	18.487	0.987	1.85E+02	2.5	7.76E+01	3.5	8.23E+00	1.8	2.73E+00	1.9
18.487	19.475	0.987	3.07E+02	1.8	1.01E+02	3.1	8.96E+00	1.8	3.13E+00	1.8
19.475	20.462	0.987	3.64E+02	1.7	1.02E+02	3.1	1.14E+01	1.6	3.62E+00	1.7
20.462	21.450	0.987	3.12E+02	1.7	9.47E+01	3.1	8.27E+00	1.9	2.72E+00	2.0
21.450	22.437	0.987	1.66E+02	2.4	8.13E+01	3.4	7.57E+00	1.9	2.46E+00	2.0
22.437	23.425	0.987	8.89E+01	3.7	5.81E+01	3.8	4.55E+00	2.5	1.86E+00	2.3
23.425	24.412	0.987	1.02E+02	2.9	5.24E+01	4.5	4.33E+00	2.4	1.82E+00	2.3
24.412	25.399	0.987	9.27E+01	3.1	3.88E+01	4.8	3.59E+00	2.7	1.24E+00	2.6
25.399	26.387	0.987	7.54E+01	3.8	3.00E+01	5.6	1.80E+00	3.8	6.52E-01	3.6
26.387	27.374	0.987	4.79E+01	3.1	2.10E+01	5.1	2.24E+00	3.6	8.02E-01	3.5
27.374	28.362	0.987	3.83E+01	0.8	2.09E+01	1.2	1.44E+00	4.2	5.32E-01	4.1
28.362	29.349	0.987	2.83E+01	1.0	1.78E+01	1.3	1.44E+00	4.3	4.69E-01	4.3
29.349	30.337	0.987	1.47E+01	1.4	1.26E+01	1.5	1.32E+00	5.0	3.96E-01	4.8
30.337	31.324	0.987	1.32E+01	1.4	9.02E+00	1.8	8.22E-01	6.0	2.78E-01	5.8
31.324	32.311	0.987	1.89E+01	1.2	7.15E+00	1.9	6.53E-01	7.6	2.26E-01	6.5
32.311	33.299	0.987	1.76E+01	1.3	7.00E+00	2.5	5.89E-01	7.4	2.09E-01	7.1
33.299	34.286	0.987	1.27E+01	1.5	5.74E+00	2.4	5.33E-01	7.4	1.73E-01	7.3
34.286	35.274	0.987	7.68E+00	1.9	3.90E+00	2.6	3.49E-01	9.9	1.24E-01	8.5
35.274	36.261	0.987	5.56E+00	2.4	3.62E+00	2.8	2.67E-01	11.0	8.46E-02	10.5
36.261	37.249	0.987	5.01E+00	2.3	2.64E+00	3.2	2.23E-01	11.5	7.05E-02	11.2
37.249	38.236	0.987	3.62E+00	2.8	3.14E+00	2.8	1.91E-01	11.3	5.73E-02	13.0
38.236	39.736	1.500	3.98E+01	4.2	3.40E+00	2.1	1.97E-01	10.8	4.63E-02	11.4
39.736	41.236	1.500	1.81E+01	6.7	4.75E+00	1.9	2.51E-01	8.8	7.26E-02	9.0
41.236	42.369	1.133	8.23E+00	10.3	5.39E+00	2.2	2.54E-01	9.5	9.72E-02	9.3
42.369	43.503	1.133	7.07E+00	11.6	4.56E+00	2.5	3.71E-01	7.8	1.08E-01	9.1
43.503	44.636	1.133	2.88E+00	17.0	4.02E+00	2.5	3.51E-01	8.5	1.15E-01	9.2
44.636	46.136	1.500	4.77E+00	12.0	3.01E+00	2.7	1.31E-01	11.4	4.48E-02	12.1
46.136	47.636	1.500	1.57E+00	21.4	1.73E+00	3.7	7.69E-02	18.9	2.33E-02	14.7
47.636	48.818	1.182	2.59E+00	16.6	1.00E+00	5.0	8.73E-02	18.0	2.27E-02	18.7
48.818	50.000	1.182	1.21E+00	22.3	8.79E-01	4.8	2.79E-02	24.5	1.55E-02	22.8
50.000	51.175	1.175	6.01E+00	11.9	1.49E+00	4.1	1.12E-01	15.1	3.25E-02	17.7
51.175	52.350	1.175	1.04E+01	10.3	2.12E+00	3.8	1.11E-01	15.0	4.27E-02	17.5
52.350	53.525	1.175	9.13E+00	10.5	1.93E+00	3.5	8.67E-02	17.8	3.21E-02	16.6
53.525	54.700	1.175	5.41E+00	13.1	1.23E+00	4.1	1.18E-01	15.5	2.67E-02	16.9
54.700	55.874	1.175	1.81E+00	18.5	1.18E+00	4.6	3.88E-02	19.8	2.43E-02	21.3
55.874	57.049	1.175	2.47E+00	21.7	8.74E-01	4.7	4.02E-02	20.0	1.53E-02	20.6
57.049	58.224	1.175	2.74E+00	21.0	9.84E-01	5.7	5.16E-02	21.5	1.07E-02	26.7
58.224	59.399	1.175	9.19E-01	30.1	8.04E-01	4.9	4.32E-02	20.5	1.44E-02	22.3
59.399	60.574	1.175	8.03E+00	11.7	8.12E-01	5.0	4.57E-02	21.0	1.52E-02	20.2
60.574	62.074	1.500	7.14E+00	9.3	1.30E+00	3.4	5.05E-02	16.7	1.52E-02	17.7
62.074	63.574	1.500	2.10E+00	18.8	1.36E+00	4.0	7.68E-02	14.5	1.43E-02	20.2
63.574	64.707	1.133	1.36E+00	24.5	8.41E-01	5.5	4.43E-02	20.0	1.36E-02	22.7
64.707	65.841	1.133	5.09E+00	12.0	8.36E-01	5.1	2.99E-02	21.4	1.17E-02	22.2
65.841	66.974	1.133	3.25E+00	15.7	6.83E-01	5.1	4.28E-02	22.1	1.96E-02	20.1
66.974	68.474	1.500	1.71E+00	17.0	1.51E+00	3.6	1.09E-01	12.2	2.50E-02	15.1
68.474	69.974	1.500	1.73E+00	21.1	4.29E-01	6.6	6.93E-02	16.5	2.80E-02	15.9
69.974	71.341	1.367	9.81E-01	23.8	4.66E-01	6.4	2.22E-02	26.7	4.83E-03	28.0

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 7 continued (6/9).

INJECTION Prompt dose INWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)									
		Detector*		IC1		IC2		IC3		IC4	
		IC1	IC2	IC3	IC4	IC5	IC6	IC7	IC8		
-8.349	-7.349	1.000	6.76E+01	49.4	1.43E+01	11.7	7.03E+00	15.9	1.72E+00	22.9	
-7.349	-6.299	1.050	1.57E+02	37.1	3.85E+01	6.6	8.62E+00	11.3	2.98E+00	17.8	
-6.299	-5.249	1.050	2.34E+02	23.5	7.01E+01	5.0	2.12E+01	8.3	5.67E+00	19.1	
-5.249	-4.199	1.050	4.36E+02	33.4	1.17E+02	4.0	3.49E+01	6.5	1.11E+01	9.6	
-4.199	-3.150	1.050	3.49E+02	19.8	1.60E+02	3.5	4.87E+01	5.2	1.33E+01	9.0	
-3.150	-2.100	1.050	3.19E+02	20.3	6.49E+01	5.6	2.21E+01	8.2	7.90E+00	12.0	
-2.100	-1.050	1.050	5.16E+02	16.7	1.57E+02	3.8	2.75E+01	6.8	4.56E+00	13.5	
-1.050	0.000	1.050	4.88E+02	27.4	1.30E+02	3.9	4.21E+01	6.0	1.14E+01	11.6	
0.000	1.000	1.000	6.59E+02	16.8	1.24E+02	3.8	3.05E+01	6.8	9.09E+00	11.6	
1.000	2.000	1.000	9.92E+02	18.5	1.78E+02	3.4	3.66E+01	6.5	9.05E+00	10.4	
2.000	3.000	1.000	1.09E+03	17.4	1.68E+02	4.5	3.61E+01	6.7	9.53E+00	9.9	
3.000	4.000	1.000	1.61E+03	16.5	2.04E+02	3.6	4.82E+01	6.3	1.28E+01	10.3	
4.000	5.000	1.000	1.71E+03	19.9	1.82E+02	3.9	5.04E+01	6.0	1.28E+01	10.1	
5.000	6.000	1.000	1.91E+03	20.4	1.25E+02	5.0	2.63E+01	8.2	8.85E+00	11.2	
6.000	7.000	1.000	1.76E+03	14.8	2.22E+02	3.9	4.29E+01	7.2	9.24E+00	11.7	
7.000	8.000	1.000	1.41E+03	15.7	2.51E+02	3.7	3.64E+01	7.0	8.89E+00	12.5	
8.000	9.000	1.000	2.23E+03	15.9	2.28E+02	3.5	5.50E+01	6.4	1.09E+01	10.3	
9.000	10.000	1.000	2.82E+03	16.4	2.21E+02	3.5	6.20E+01	5.4	1.55E+01	9.2	
10.000	11.000	1.000	3.36E+03	14.2	3.19E+02	2.9	6.34E+01	5.3	1.42E+01	9.1	
11.000	12.000	1.000	4.17E+03	11.6	4.14E+02	2.3	8.50E+01	4.0	2.35E+01	6.6	
12.000	13.000	1.000	6.19E+03	8.8	7.93E+02	1.6	1.93E+02	2.7	5.31E+01	4.5	
13.000	14.000	1.000	1.32E+04	6.1	1.89E+03	1.0	4.35E+02	1.8	1.07E+02	3.2	
14.000	15.000	1.000	1.21E+04	5.3	2.25E+03	0.9	5.82E+02	1.6	1.56E+02	2.7	
15.000	15.833	0.833	8.56E+03	8.1	1.58E+03	1.3	4.53E+02	2.0	1.41E+02	3.1	
15.833	16.667	0.833	1.02E+04	13.9	1.69E+03	1.3	4.63E+02	1.9	1.30E+02	3.2	
16.667	17.500	0.833	8.28E+03	8.0	1.71E+03	1.2	4.40E+02	2.0	1.27E+02	3.2	
17.500	18.487	0.987	9.29E+03	6.3	1.82E+03	1.1	4.70E+02	1.8	1.34E+02	2.9	
18.487	19.475	0.987	1.11E+04	6.5	1.81E+03	1.1	5.68E+02	1.7	1.51E+02	2.7	
19.475	20.462	0.987	1.46E+04	6.3	2.20E+03	1.0	5.95E+02	1.6	1.65E+02	2.6	
20.462	21.450	0.987	1.15E+04	5.6	2.38E+03	0.9	6.51E+02	1.5	1.89E+02	2.4	
21.450	22.437	0.987	8.53E+03	5.3	2.04E+03	1.1	5.99E+02	1.7	1.80E+02	2.7	
22.437	23.425	0.987	8.24E+03	5.9	2.15E+03	1.1	5.86E+02	1.7	1.71E+02	2.7	
23.425	24.412	0.987	9.07E+03	5.3	1.88E+03	1.1	5.26E+02	1.8	1.56E+02	2.8	
24.412	25.399	0.987	1.05E+04	5.6	2.31E+03	1.0	5.94E+02	1.6	1.68E+02	2.7	
25.399	26.387	0.987	7.61E+03	7.0	1.78E+03	1.2	4.73E+02	1.9	1.46E+02	3.0	
26.387	27.374	0.987	6.49E+03	7.3	1.40E+03	1.4	4.19E+02	2.1	1.29E+02	3.2	
27.374	28.362	0.987	5.64E+03	8.4	1.16E+03	1.6	3.32E+02	2.4	1.07E+02	3.7	
28.362	29.349	0.987	5.01E+03	11.3	9.59E+02	1.7	2.96E+02	2.6	8.52E+01	4.0	
29.349	30.337	0.987	4.34E+03	12.5	7.20E+02	2.0	1.90E+02	2.9	6.03E+01	4.7	
30.337	31.324	0.987	2.93E+03	14.5	6.86E+02	2.1	1.72E+02	3.3	4.65E+01	5.1	
31.324	32.311	0.987	3.55E+03	9.8	6.87E+02	2.0	1.66E+02	3.3	4.07E+01	5.4	
32.311	33.299	0.987	3.33E+03	13.6	6.27E+02	2.2	1.39E+02	3.5	3.86E+01	5.6	
33.299	34.286	0.987	2.07E+03	15.9	4.45E+02	2.9	9.66E+01	4.5	3.00E+01	7.1	
34.286	35.274	0.987	2.06E+03	18.9	4.01E+02	3.6	1.04E+02	4.5	2.88E+01	7.2	
35.274	36.261	0.987	1.95E+03	18.3	2.73E+02	3.6	8.85E+01	5.0	2.38E+01	7.7	
36.261	37.249	0.987	7.75E+02	17.7	2.37E+02	4.0	6.58E+01	5.8	2.05E+01	8.6	
37.249	38.236	0.987	1.16E+03	22.2	1.56E+02	4.3	4.93E+01	6.0	1.33E+01	9.2	
38.236	39.736	1.500	1.62E+03	21.6	6.97E+01	6.0	1.86E+01	9.0	4.59E+00	12.6	
39.736	41.236	1.500	7.09E+02	23.4	4.14E+01	6.1	1.36E+01	11.3	2.75E+00	14.2	
41.236	42.369	1.133	1.73E+03	22.1	1.55E+02	3.9	1.86E+01	8.5	4.70E+00	13.6	
42.369	43.503	1.133	1.14E+03	25.8	1.39E+02	4.9	2.33E+01	7.7	4.92E+00	14.2	
43.503	44.636	1.133	6.44E+02	34.2	5.93E+01	6.4	2.11E+01	8.9	4.85E+00	16.9	
44.636	46.136	1.500	2.69E+01	86.1	2.20E+01	11.0	3.71E+00	19.8	1.45E+00	28.1	
46.136	47.636	1.500	2.67E+01	70.3	7.72E+00	15.5	1.30E+00	34.4	6.22E-01	65.2	
47.636	48.818	1.182	1.68E+02	66.1	7.17E-01	49.2	4.78E-01	56.4			
48.818	50.000	1.182	3.92E+01	50.0	4.46E-01	78.1					
50.000	51.175	1.175	2.15E+02	55.7							
51.175	52.350	1.175	3.56E+01	59.3	2.55E+00	21.5					
52.350	53.525	1.175	1.06E+01	97.3	1.11E+01	13.2					
53.525	54.700	1.175	1.65E+02	78.3	6.25E-01	33.7					
54.700	55.874	1.175	1.58E+02	99.2	2.07E+00	31.8					
55.874	57.049	1.175	1.70E+01	100.0	7.77E+00	17.9					
57.049	58.224	1.175	8.38E+01	100.0	1.63E-01	100.0					
58.224	59.399	1.175	3.60E+02	51.7	7.05E+00	13.4					
59.399	60.574	1.175	1.05E+02	60.8	1.70E+00	25.4					
60.574	62.074	1.500	1.35E+02	79.8	4.60E+00	15.8					
62.074	63.574	1.500	4.03E+01	69.3	6.17E+00	16.1					
63.574	64.707	1.133	4.65E+01	74.0	1.09E+00	31.5					
64.707	65.841	1.133	4.84E+01	51.3							
65.841	66.974	1.133	1.32E+02	51.1	2.91E+00	22.0					
66.974	68.474	1.500	1.79E-01	100.0							
68.474	69.974	1.500	9.55E+00	100.0							
69.974	71.341	1.367	1.13E+01	69.7							

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 7 continued (7/9).

INJECTION Prompt dose INWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)						
		Detector* IC5	ICa	IS1	IS2			
-8.349	-7.349	1.000		4.74E-01	8.3	1.27E-01	8.7	
-7.349	-6.299	1.050		7.01E-01	5.6	2.64E-01	5.8	
-6.299	-5.249	1.050		1.83E+00	3.5	4.80E-01	4.2	
-5.249	-4.199	1.050		2.76E+00	2.9	8.46E-01	3.4	
-4.199	-3.150	1.050		4.16E+00	2.8	1.33E+00	3.2	
-3.150	-2.100	1.050		2.49E+00	3.2	1.05E+00	3.3	
-2.100	-1.050	1.050		1.76E+00	3.9	6.56E-01	3.6	
-1.050	0.000	1.050		3.08E+00	2.9	7.70E-01	3.3	
0.000	1.000	1.000		2.45E+00	3.5	6.76E-01	3.7	
1.000	2.000	1.000		2.77E+00	3.1	6.55E-01	3.5	
2.000	3.000	1.000		2.85E+00	3.1	9.12E-01	3.1	
3.000	4.000	1.000		2.79E+00	3.4	1.08E+00	3.2	
4.000	5.000	1.000		2.70E+00	3.3	8.61E-01	3.3	
5.000	6.000	1.000		2.15E+00	3.5	7.99E-01	3.3	
6.000	7.000	1.000		2.42E+00	3.6	6.36E-01	3.6	
7.000	8.000	1.000		2.71E+00	3.2	7.80E-01	3.4	
8.000	9.000	1.000		3.11E+00	2.9	9.58E-01	3.1	
9.000	10.000	1.000		4.19E+00	2.5	1.24E+00	2.7	
10.000	11.000	1.000	4.13E+00	2.6	6.52E-01	6.5	2.08E-01	6.6
11.000	12.000	1.000	5.66E+00	2.1	7.82E-01	5.7	2.95E-01	5.4
12.000	13.000	1.000	1.49E+01	1.3	2.16E+00	3.3	7.65E-01	3.4
13.000	14.000	1.000	2.96E+01	0.9	4.47E+00	2.4	1.37E+00	2.6
14.000	15.000	1.000	4.24E+01	0.8	6.47E+00	2.1	2.00E+00	2.2
15.000	15.833	0.833	4.57E+01	0.9	7.09E+00	2.1	2.21E+00	2.2
15.833	16.667	0.833	3.98E+01	0.9	6.21E+00	2.3	2.02E+00	2.3
16.667	17.500	0.833	3.50E+01	1.0	5.77E+00	2.4	1.87E+00	2.4
17.500	18.487	0.987	3.96E+01	0.8	5.90E+00	2.2	1.87E+00	2.2
18.487	19.475	0.987	4.35E+01	0.8	7.03E+00	2.0	2.23E+00	2.1
19.475	20.462	0.987	4.82E+01	0.7	7.50E+00	1.9	2.46E+00	2.0
20.462	21.450	0.987	5.40E+01	0.7	8.66E+00	1.8	2.61E+00	1.9
21.450	22.437	0.987	5.10E+01	0.7	8.28E+00	1.8	2.61E+00	1.9
22.437	23.425	0.987	4.90E+01	0.8	7.47E+00	1.9	2.42E+00	2.0
23.425	24.412	0.987	4.40E+01	0.8	6.71E+00	2.0	2.28E+00	2.0
24.412	25.399	0.987	4.64E+01	0.8	7.10E+00	2.0	2.36E+00	2.0
25.399	26.387	0.987	4.29E+01	0.8	6.80E+00	2.0	2.26E+00	2.0
26.387	27.374	0.987	3.72E+01	0.9	5.84E+00	2.2	2.04E+00	2.2
27.374	28.362	0.987	3.09E+01	1.0	5.06E+00	2.4	1.61E+00	2.4
28.362	29.349	0.987	2.48E+01	1.1	4.05E+00	2.6	1.35E+00	2.7
29.349	30.337	0.987	1.89E+01	1.3	3.40E+00	3.0	9.74E-01	3.0
30.337	31.324	0.987	1.34E+01	1.4	2.11E+00	3.8	7.02E-01	3.7
31.324	32.311	0.987	1.20E+01	1.6	1.82E+00	3.8	5.62E-01	4.0
32.311	33.299	0.987	1.04E+01	1.6	1.71E+00	3.9	5.21E-01	4.2
33.299	34.286	0.987	7.94E+00	2.0	1.17E+00	5.0	3.88E-01	4.8
34.286	35.274	0.987	6.80E+00	2.1	1.11E+00	5.1	3.69E-01	5.0
35.274	36.261	0.987	6.74E+00	2.1	9.96E-01	5.5	3.27E-01	5.3
36.261	37.249	0.987	5.54E+00	2.4	9.00E-01	5.6	2.71E-01	5.9
37.249	38.236	0.987	4.91E+00	2.6	8.31E-01	6.0	2.40E-01	6.5
38.236	39.736	1.500	1.57E+00	3.4	6.68E-01	10.2	5.18E-02	8.7
39.736	41.236	1.500	8.94E-01	5.8	5.74E-01	10.6	3.76E-02	9.2
41.236	42.369	1.133	2.20E+00	3.9	3.24E-01	8.6	1.54E-01	7.4
42.369	43.503	1.133	1.21E+00	4.4	2.14E-01	10.6	7.88E-02	10.5
43.503	44.636	1.133	1.38E+00	4.3	1.43E-01	12.5	5.52E-02	13.8
44.636	46.136	1.500	2.45E-01	9.6	1.04E-01	19.1	1.11E-02	20.1
46.136	47.636	1.500	5.02E-02	19.2	7.96E-02	25.3	8.00E-03	20.9
47.636	48.818	1.182			5.17E-02	19.1	1.17E-02	19.7
48.818	50.000	1.182			1.17E-02	74.6	2.08E-02	48.8
50.000	51.175	1.175			9.29E-02	100.0	9.59E-03	54.6
51.175	52.350	1.175			1.97E-01	52.7	6.10E-02	35.1
52.350	53.525	1.175			3.26E+00	15.4	9.25E-01	12.1
53.525	54.700	1.175			6.22E-01	34.0	8.73E-01	14.2
54.700	55.874	1.175			5.54E-01	34.8	2.25E-01	22.9
55.874	57.049	1.175			1.88E+00	20.6	4.32E-01	17.9
57.049	58.224	1.175			9.90E-02	71.9	9.06E-02	35.8
58.224	59.399	1.175			4.78E-01	37.0	1.31E-01	33.4
59.399	60.574	1.175			8.12E-01	27.3	1.88E-01	24.5
60.574	62.074	1.500			1.47E+00	28.3	1.24E-01	27.7
62.074	63.574	1.500			2.15E+00	22.3	3.00E-01	20.4
63.574	64.707	1.133			2.96E+00	16.2	7.76E-01	15.4
64.707	65.841	1.133			9.66E-03	95.7	8.01E-02	20.4
65.841	66.974	1.133			1.63E-02	92.8	5.51E-02	49.7
66.974	68.474	1.500					6.32E-05	100.0
68.474	69.974	1.500						2.16E-02
69.974	71.341	1.367			8.32E-02	58.0		9.13E-02

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 7 continued (8/9).

INJECTION Prompt dose OUTWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)						
		Detector*		OC2		OC3		
		OC1						
-8.349	-7.349	1.000	1.14E+02	48.8	2.59E+01	9.5	3.83E+00	17.2
-7.349	-6.299	1.050	7.56E+01	45.8	1.88E+01	10.1	6.57E+00	13.0
-6.299	-5.249	1.050	2.07E+02	26.5	4.52E+01	6.1	1.22E+01	10.9
-5.249	-4.199	1.050	5.04E+02	18.8	1.12E+02	3.7	2.84E+01	6.5
-4.199	-3.150	1.050	4.76E+02	17.6	1.79E+02	3.4	4.47E+01	5.3
-3.150	-2.100	1.050	9.27E+02	18.0	1.40E+02	4.1	4.58E+01	6.3
-2.100	-1.050	1.050	1.21E+03	17.8	1.60E+02	3.6	4.06E+01	6.8
-1.050	0.000	1.050	1.08E+03	16.1	2.61E+02	2.9	5.70E+01	5.0
0.000	1.000	1.000	1.47E+03	11.9	3.07E+02	3.2	6.34E+01	5.0
1.000	2.000	1.000	1.64E+03	16.6	2.93E+02	3.5	7.90E+01	5.5
2.000	3.000	1.000	2.27E+03	15.5	1.94E+02	3.7	6.51E+01	5.5
3.000	4.000	1.000	2.10E+03	17.8	2.51E+02	3.6	5.40E+01	6.4
4.000	5.000	1.000	1.87E+03	19.9	1.73E+02	4.3	3.96E+01	6.3
5.000	6.000	1.000	1.78E+03	18.4	1.89E+02	4.0	3.16E+01	7.6
6.000	7.000	1.000	1.68E+03	16.7	1.15E+02	4.9	2.49E+01	8.4
7.000	8.000	1.000	1.09E+03	24.9	1.17E+02	5.4	2.80E+01	8.2
8.000	9.000	1.000	1.73E+03	27.2	1.44E+02	4.6	3.10E+01	7.6
9.000	10.000	1.000	1.64E+03	19.7	1.06E+02	4.7	3.04E+01	7.3
10.000	11.000	1.000	1.88E+03	12.9	2.17E+02	3.4	5.02E+01	5.7
11.000	12.000	1.000	2.65E+03	12.8	3.36E+02	2.4	8.65E+01	4.1
12.000	13.000	1.000	5.56E+03	6.8	9.78E+02	1.3	2.19E+02	2.5
13.000	14.000	1.000	2.00E+04	3.8	2.88E+03	0.8	6.03E+02	1.5
14.000	15.000	1.000	1.42E+04	4.3	2.82E+03	0.8	7.01E+02	1.4
15.000	15.833	0.833	1.18E+04	5.8	2.90E+03	0.9	9.21E+02	1.3
15.833	16.667	0.833	1.38E+04	8.6	3.05E+03	0.9	1.09E+03	1.2
16.667	17.500	0.833	1.98E+04	4.9	3.03E+03	0.9	1.08E+03	1.4
17.500	18.487	0.987	1.72E+04	4.5	3.39E+03	0.8	9.95E+02	1.3
18.487	19.475	0.987	2.39E+04	3.3	4.55E+03	0.7	1.12E+03	1.2
19.475	20.462	0.987	4.53E+04	2.3	7.91E+03	0.5	1.80E+03	0.9
20.462	21.450	0.987	2.62E+04	3.3	6.39E+03	0.6	1.71E+03	1.0
21.450	22.437	0.987	1.85E+04	5.1	4.00E+03	0.8	1.14E+03	1.2
22.437	23.425	0.987	1.45E+04	5.3	2.76E+03	1.0	7.47E+02	1.6
23.425	24.412	0.987	1.80E+04	4.1	3.06E+03	0.9	7.35E+02	1.5
24.412	25.399	0.987	1.93E+04	4.2	3.34E+03	0.8	8.14E+02	1.4
25.399	26.387	0.987	1.17E+04	5.6	2.53E+03	1.0	6.33E+02	1.6
26.387	27.374	0.987	1.10E+04	5.9	2.27E+03	1.2	5.66E+02	1.8
27.374	28.362	0.987	5.30E+03	7.3	1.12E+03	1.6	3.53E+02	2.3
28.362	29.349	0.987	4.39E+03	9.7	7.16E+02	1.9	2.18E+02	2.9
29.349	30.337	0.987	4.48E+03	11.0	6.13E+02	2.3	1.42E+02	3.5
30.337	31.324	0.987	4.14E+03	10.9	5.90E+02	2.9	1.43E+02	3.7
31.324	32.311	0.987	6.85E+03	9.8	7.73E+02	1.7	1.69E+02	3.0
32.311	33.299	0.987	4.47E+03	13.8	5.89E+02	1.9	1.47E+02	3.3
33.299	34.286	0.987	2.54E+03	11.6	4.31E+02	2.6	1.13E+02	3.8
34.286	35.274	0.987	2.26E+03	11.9	3.41E+02	2.7	8.24E+01	4.7
35.274	36.261	0.987	2.54E+03	13.4	2.97E+02	3.0	7.68E+01	4.6
36.261	37.249	0.987	3.20E+03	16.1	2.57E+02	3.5	6.29E+01	5.7
37.249	38.236	0.987	2.23E+03	15.5	2.19E+02	3.7	4.65E+01	6.1
38.236	39.736	1.500	2.61E+03	14.1	2.16E+02	3.1	4.85E+01	5.6
39.736	41.236	1.500	1.66E+03	20.9	1.90E+02	3.7	5.84E+01	5.4
41.236	42.369	1.133	1.38E+03	30.0	1.03E+02	5.5	1.65E+01	9.7
42.369	43.503	1.133	4.38E+02	42.6	5.04E+01	9.6	1.53E+01	10.7
43.503	44.636	1.133	4.44E+02	53.8	1.06E+01	12.0	3.97E+00	29.5
44.636	46.136	1.500	2.09E+02	36.8	7.54E+00	13.1	1.41E+00	30.1
46.136	47.636	1.500	6.59E+02	32.9	3.15E+01	17.9	1.98E+00	20.9
47.636	48.818	1.182	5.08E+02	59.2	6.36E+01	9.5	1.26E+01	14.7
48.818	50.000	1.182	5.04E+02	52.9	5.93E+00	29.2	7.57E+00	15.8
50.000	51.175	1.175	3.38E+02	64.1	7.13E-01	44.5	2.50E+00	35.2
51.175	52.350	1.175	1.25E+02	58.3	7.03E+00	15.9	4.23E+00	20.4
52.350	53.525	1.175	1.14E+02	45.2	1.00E+01	14.6	3.66E+00	24.6
53.525	54.700	1.175	4.09E+02	42.7	1.06E+01	16.5	2.72E+00	21.2
54.700	55.874	1.175	2.82E+01	93.3	3.22E+00	24.1	2.04E+00	24.3
55.874	57.049	1.175	1.51E+02	37.5	1.22E+01	11.6	1.59E+00	24.3
57.049	58.224	1.175	9.25E+01	50.6	1.49E+01	13.8	3.44E+00	20.8
58.224	59.399	1.175	1.27E+02	45.4	1.96E+01	10.0	2.08E+00	20.1
59.399	60.574	1.175	1.79E+02	67.3	9.66E+00	11.0	1.88E+00	26.1
60.574	62.074	1.500	9.68E+01	59.0	3.41E+01	8.4	1.03E+01	10.1
62.074	63.574	1.500	8.56E+01	35.6	1.90E+01	11.0	4.09E+00	18.4
63.574	64.707	1.133	2.01E+02	72.4	4.32E+00	19.4	1.39E+00	24.2
64.707	65.841	1.133	7.06E+01	63.8	6.19E+00	14.8	4.72E+00	22.8
65.841	66.974	1.133	6.34E+01	56.7	1.92E+00	30.0	1.62E+00	31.7
66.974	68.474	1.500	3.00E+02	53.7	1.43E+01	10.8	3.88E+00	18.8
68.474	69.974	1.500	1.71E+02	81.6	1.91E+01	9.0	5.69E+00	14.3
69.974	71.341	1.367	6.26E+01	83.9	1.21E+01	17.4		

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 7 continued (9/9).

INJECTION Prompt dose OUTWARD		Length (m)	Prompt-dose-rate(mSv/h) Error(%)							
Location-range (m)	Detector*		OC5	OCa	OS1	OS2				
-8.349	-7.349	1.000		1.26E+00	31.5	1.27E-01	8.7	5.71E-02	18.8	
-7.349	-6.299	1.050		2.34E+00	19.4	2.64E-01	5.8	5.60E-03	44.2	
-6.299	-5.249	1.050		2.71E+00	16.0	4.80E-01	4.2	8.91E-02	17.3	
-5.249	-4.199	1.050		2.94E+00	4.7	8.46E-01	3.4	4.68E-02	17.6	
-4.199	-3.150	1.050		3.47E+00	2.6	1.33E+00	3.2	7.62E-02	17.1	
-3.150	-2.100	1.050		4.35E+00	2.5	1.05E+00	3.3	1.23E-01	12.1	
-2.100	-1.050	1.050		3.81E+00	2.8	6.56E-01	3.6	5.02E-02	14.5	
-1.050	0.000	1.050		3.24E+00	2.8	7.70E-01	3.3	4.33E-02	21.0	
0.000	1.000	1.000		4.82E+00	2.4	6.76E-01	3.7	1.42E-01	13.5	
1.000	2.000	1.000		5.07E+00	2.6	6.55E-01	3.5	9.53E-02	16.7	
2.000	3.000	1.000		4.66E+00	2.6	9.12E-01	3.1	1.49E-01	13.7	
3.000	4.000	1.000		3.98E+00	3.0	1.08E+00	3.2	2.68E-02	26.6	
4.000	5.000	1.000		2.03E+00	3.7	8.61E-01	3.3	1.22E-01	11.9	
5.000	6.000	1.000		1.85E+00	4.1	7.99E-01	3.3	6.37E-02	15.8	
6.000	7.000	1.000		1.71E+00	4.2	6.36E-01	3.6	9.23E-02	15.5	
7.000	8.000	1.000		2.01E+00	3.7	7.80E-01	3.4	1.22E-01	13.9	
8.000	9.000	1.000		2.12E+00	3.5	9.58E-01	3.1	1.71E-01	11.0	
9.000	10.000	1.000		2.01E+00	3.6	1.24E+00	2.7	2.59E-02	21.6	
10.000	11.000	1.000	3.54E+00	2.8	9.57E-01	5.5	2.08E-01	6.6	1.08E-01	14.4
11.000	12.000	1.000	6.46E+00	2.0	1.49E+00	4.2	2.95E-01	5.4	1.00E-01	13.8
12.000	13.000	1.000	1.46E+01	1.3	3.50E+00	2.7	7.65E-01	3.4	2.15E-01	9.1
13.000	14.000	1.000	3.88E+01	0.8	8.28E+00	1.7	1.37E+00	2.6	3.77E-01	7.1
14.000	15.000	1.000	4.70E+01	0.7	1.11E+01	1.5	2.00E+00	2.2	6.34E-01	5.5
15.000	15.833	0.833	8.58E+01	0.6	1.08E+01	1.7	2.21E+00	2.2	4.96E-01	6.4
15.833	16.667	0.833	1.39E+02	0.5	8.36E+00	2.0	2.02E+00	2.3	8.47E-01	5.4
16.667	17.500	0.833	1.49E+02	0.4	4.13E+00	2.8	1.87E+00	2.4	8.75E-01	5.1
17.500	18.487	0.987	1.11E+02	0.5	1.27E+01	1.5	1.87E+00	2.2	1.17E+00	5.1
18.487	19.475	0.987	9.42E+01	0.6	8.49E+00	1.8	2.23E+00	2.1	7.65E-01	4.9
19.475	20.462	0.987	1.25E+02	0.5	9.42E+00	1.7	2.46E+00	2.0	1.48E+00	3.7
20.462	21.450	0.987	1.25E+02	0.5	9.13E+00	1.8	2.61E+00	1.9	1.78E+00	3.3
21.450	22.437	0.987	9.50E+01	0.5	7.29E+00	2.0	2.61E+00	1.9	1.51E+00	3.8
22.437	23.425	0.987	6.59E+01	0.7	5.41E+00	2.3	2.42E+00	2.0	1.13E+00	4.6
23.425	24.412	0.987	5.56E+01	0.7	4.61E+00	2.5	2.28E+00	2.0	8.64E-01	5.6
24.412	25.399	0.987	5.77E+01	0.7	4.43E+00	2.5	2.36E+00	2.0	7.37E-01	5.3
25.399	26.387	0.987	5.00E+01	0.7	3.64E+00	2.8	2.26E+00	2.0	6.78E-01	5.1
26.387	27.374	0.987	4.41E+01	0.8	3.30E+00	2.8	2.04E+00	2.2	8.07E-01	5.7
27.374	28.362	0.987	3.01E+01	1.0	2.32E+00	3.4	1.61E+00	2.4	3.56E-01	7.5
28.362	29.349	0.987	1.99E+01	1.3	1.57E+00	4.1	1.35E+00	2.7	2.24E-01	8.9
29.349	30.337	0.987	1.34E+01	1.5	1.18E+00	4.9	9.74E-01	3.0	2.03E-01	9.3
30.337	31.324	0.987	1.01E+01	1.7	9.15E-01	6.4	7.02E-01	3.7	1.61E-01	10.9
31.324	32.311	0.987	1.17E+01	1.5	8.65E-01	5.5	5.62E-01	4.0	1.48E-01	11.3
32.311	33.299	0.987	1.16E+01	1.6	8.05E-01	6.5	5.21E-01	4.2	1.65E-01	11.1
33.299	34.286	0.987	8.14E+00	1.8	5.66E-01	6.7	3.88E-01	4.8	2.29E-01	9.3
34.286	35.274	0.987	6.33E+00	2.1	5.27E-01	7.4	3.69E-01	5.0	1.45E-01	12.0
35.274	36.261	0.987	3.87E+00	2.6	2.76E-01	9.6	3.27E-01	5.3	1.19E-01	13.0
36.261	37.249	0.987	4.57E+00	2.7	3.07E-01	9.0	2.71E-01	5.9	1.44E-01	11.3
37.249	38.236	0.987	3.08E+00	3.0	2.26E-01	11.9	2.40E-01	6.5	8.24E-02	16.0
38.236	39.736	1.500	3.11E+00	2.6	1.29E-01	10.4	5.18E-02	8.7	5.36E-01	23.7
39.736	41.236	1.500	4.80E+00	2.1	3.21E-01	6.9	3.76E-02	9.2	5.87E-01	20.7
41.236	42.369	1.133			6.63E-01	6.4	1.54E-01	7.4	2.71E-01	35.8
42.369	43.503	1.133			7.24E-01	6.4	7.88E-02	10.5	1.79E-01	45.9
43.503	44.636	1.133			5.76E-01	7.3	5.52E-02	13.8	3.28E-01	33.4
44.636	46.136	1.500			5.42E-01	27.7	1.11E-02	20.1	2.12E-01	35.2
46.136	47.636	1.500			6.90E-01	24.2	8.00E-03	20.9		
47.636	48.818	1.182			4.22E+00	14.4	1.17E-02	19.7	1.08E-02	32.8
48.818	50.000	1.182			3.12E+00	17.8	2.08E-02	48.8	8.59E-03	98.5
50.000	51.175	1.175			2.89E+00	18.8	9.59E-03	54.6	3.95E-03	57.8
51.175	52.350	1.175			1.63E+00	32.8	6.10E-02	35.1	8.24E-03	29.9
52.350	53.525	1.175			9.00E-01	29.4	9.25E-01	12.1	5.62E-03	100.0
53.525	54.700	1.175			1.94E+00	23.7	8.73E-01	14.2	3.60E-02	99.3
54.700	55.874	1.175			5.96E-01	34.9	2.25E-01	22.9	7.84E-02	98.8
55.874	57.049	1.175			1.28E+00	28.9	4.32E-01	17.9	6.61E-02	55.9
57.049	58.224	1.175			1.14E+00	24.4	9.06E-02	35.8	4.47E-01	32.9
58.224	59.399	1.175			7.46E-01	29.4	1.31E-01	33.4	4.30E-02	98.9
59.399	60.574	1.175			7.45E-01	29.4	1.88E-01	24.5	9.18E-02	100.0
60.574	62.074	1.500			3.38E+00	12.9	1.24E-01	27.7	5.49E-04	78.1
62.074	63.574	1.500			8.89E-01	19.6	3.00E-01	20.4	4.28E-02	76.5
63.574	64.707	1.133			1.64E+00	23.3	7.76E-01	15.4		
64.707	65.841	1.133			1.60E+00	20.7	8.01E-02	20.4	2.88E-03	71.1
65.841	66.974	1.133			1.50E+00	25.7	5.51E-02	49.7	1.03E-01	63.2
66.974	68.474	1.500			8.00E-01	20.8	6.32E-05	100.0	1.19E-01	74.5
68.474	69.974	1.500			2.01E+00	15.4			5.97E-04	81.7
69.974	71.341	1.367			5.25E+00	16.6			2.32E-04	100.0

* Detector name means

Direction - "U":upward, "D":downward, "I":inward and "O":outward.

Shield - "C":concrete and "S":soil.

Table 8: Prompt dose rates inside the concrete and soil shield in the region from the kicker through extraction.(1/9)

EXTRACTION Prompt dose UPWARD										
Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)								
		Detector*			UCs			UC2		UC3
		UC1								
108.370	109.648	1.279	2.14E+02	15.2	3.82E+02	11.6	7.01E+00	5.6	1.17E+00	13.1
109.648	110.927	1.279	2.81E+02	12.3	6.34E+02	10.0	1.06E+01	5.8	7.63E-01	15.8
110.927	112.206	1.279	6.12E+02	36.4	6.32E+02	9.6	8.02E+00	5.8	1.45E+00	12.3
112.206	113.485	1.279	6.53E+02	8.1	9.43E+02	6.9	1.89E+01	4.4	3.14E+00	7.8
113.485	114.764	1.279	8.94E+02	7.5	1.21E+03	6.1	2.21E+01	3.5	3.51E+00	7.1
114.764	116.042	1.279	1.31E+03	8.9	1.50E+03	5.9	3.99E+01	2.9	7.76E+00	4.9
116.042	117.321	1.279	1.83E+03	7.9	2.20E+03	10.3	7.35E+01	2.0	1.29E+01	4.0
117.321	118.600	1.279	2.94E+03	10.9	2.83E+03	9.0	1.26E+02	1.6	2.29E+01	3.0
118.600	119.600	1.000	3.87E+03	8.9	2.84E+03	9.0	2.18E+02	1.3	4.52E+01	2.4
119.600	120.600	1.000	5.40E+03	7.5	1.95E+03	4.7	4.11E+02	1.1	8.25E+01	1.7
120.600	121.631	1.031	8.34E+03	6.4	1.64E+03	15.8	6.47E+02	0.8	1.59E+02	2.3
121.631	122.662	1.031	1.30E+04	6.0	1.02E+03	9.4	1.03E+03	0.7	2.45E+02	1.5
122.662	123.692	1.031	9.48E+03	5.4	5.67E+02	8.7	8.40E+02	0.9	1.73E+02	1.8
123.692	124.723	1.031	1.47E+03	12.1	3.82E+02	9.8	2.29E+02	1.3	6.47E+01	2.0
124.723	125.754	1.031	8.95E+02	5.9	4.71E+02	9.6	2.34E+02	1.3	7.91E+01	1.9
125.754	126.785	1.031	1.47E+03	5.1	5.29E+02	9.7	4.06E+02	1.2	1.33E+02	2.2
126.785	127.815	1.031	1.47E+03	5.4	6.69E+02	10.0	4.52E+02	1.1	1.52E+02	1.8
127.815	128.846	1.031	9.97E+02	5.9	6.76E+02	8.6	3.03E+02	1.4	1.10E+02	2.1
128.846	129.877	1.031	7.06E+02	10.9	5.70E+02	9.8	2.25E+02	2.3	7.76E+01	2.5
129.877	130.908	1.031	4.93E+02	11.6	5.77E+02	15.6	1.22E+02	2.5	4.68E+01	2.7
130.908	131.938	1.031	8.90E+02	9.9	5.19E+02	10.3	1.35E+02	2.1	4.39E+01	2.7
131.938	132.969	1.031	2.51E+03	12.8	9.25E+02	21.9	3.45E+02	3.4	6.81E+01	2.8
132.969	134.000	1.031	3.56E+03	10.1	6.70E+02	8.8	3.88E+02	2.1	9.80E+01	2.2
134.000	135.000	1.000	4.91E+03	9.3	1.17E+03	19.6	5.54E+02	4.1	1.28E+02	2.5
135.000	136.000	1.000	4.42E+03	8.9	1.48E+03	15.1	6.44E+02	2.6	1.27E+02	2.3
136.000	137.000	1.000	3.85E+03	8.0	1.63E+03	21.1	5.97E+02	2.1	1.24E+02	2.2
137.000	138.000	1.000	3.91E+03	10.3	1.96E+03	19.1	5.31E+02	2.5	1.26E+02	2.8
138.000	139.000	1.000	3.02E+03	11.3	1.56E+03	15.4	3.31E+02	3.3	8.28E+01	3.2
139.000	140.000	1.000	3.64E+03	14.1	1.15E+03	11.6	3.92E+02	3.1	7.10E+01	3.1
140.000	141.000	1.000	2.32E+03	15.2	1.44E+03	19.5	3.04E+02	2.9	6.46E+01	3.3
141.000	142.000	1.000	2.39E+03	12.3	7.73E+02	11.8	1.93E+02	2.9	4.79E+01	3.7
142.000	143.235	1.235	1.26E+03	10.5	1.55E+03	19.7	1.81E+02	3.6	4.11E+01	3.8
143.235	144.469	1.235	1.35E+03	17.8	6.40E+02	14.9	1.59E+02	3.9	3.56E+01	4.8
144.469	145.704	1.235	1.29E+03	18.0	9.49E+02	21.8	1.50E+02	3.5	3.09E+01	3.4
145.704	146.939	1.235	8.50E+02	15.1	1.07E+03	20.8	1.07E+02	5.8	2.48E+01	4.5
146.939	148.174	1.235	7.18E+02	15.0	4.08E+02	15.7	8.51E+01	4.4	2.17E+01	5.6
148.174	149.408	1.235	9.00E+02	20.9	5.59E+02	16.9	6.43E+01	6.2	1.19E+01	8.8
149.408	150.643	1.235	8.14E+02	23.6	4.20E+02	23.7	5.83E+01	7.3	1.70E+01	10.1
150.643	151.878	1.235	4.55E+02	21.5	7.26E+02	28.9	5.18E+01	7.0	1.01E+01	5.8
151.878	153.112	1.235	8.80E+02	31.2	3.79E+02	23.5	2.68E+01	11.5	9.15E+00	19.8
153.112	154.347	1.235	2.95E+02	23.0	5.24E+02	28.7	3.62E+01	9.6	5.15E+00	9.4
154.347	155.847	1.500	1.85E+02	27.4	1.81E+02	26.9	1.63E+01	12.5	3.16E+00	16.2
155.847	157.347	1.500	2.80E+02	36.8	2.91E+02	22.2	1.03E+01	18.0	2.67E+00	14.8
157.347	159.047	1.700	1.55E+02	24.9	2.40E+02	25.5	1.86E+01	14.5		
159.047	160.747	1.700	1.88E+02	43.9	1.21E+02	35.2	1.09E+01	6.2		
160.747	162.247	1.500	1.49E+02	32.2	1.33E+02	46.7	7.72E+00	6.1		
162.247	163.747	1.500	1.59E+02	40.8	1.08E+02	43.2	4.03E+00	8.9		
163.747	165.364	1.617	4.50E+01	54.6	4.61E+01	42.0	7.96E+00	8.5		
165.364	166.981	1.617	6.40E+01	37.2	2.40E+01	73.7	7.65E+00	26.2		
166.982	168.599	1.617	2.36E+02	51.6	1.62E+01	70.1	1.94E+01	20.4		

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 8 continued (2/9).

EXTRACTION Prompt dose UPWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)					
		Detector* UC4		UC5		UC6	
108.370	109.648	1.279					5.42E-02 10.0
109.648	110.927	1.279					4.55E-02 12.0
110.927	112.206	1.279					1.22E-01 6.8
112.206	113.485	1.279					2.79E-01 4.6
113.485	114.764	1.279					3.63E-01 4.1
114.764	116.042	1.279					9.07E-01 2.7
116.042	117.321	1.279					1.33E+00 2.5
117.321	118.600	1.279					2.79E+00 1.6
118.600	119.600	1.000	1.15E+01	5.9	1.98E+00	2.2	2.16E-01 1.3
119.600	120.600	1.000	2.14E+01	3.1	4.15E+00	2.2	4.01E-01 0.9
120.600	121.631	1.031	4.01E+01	3.0	7.11E+00	1.3	7.42E-01 0.8
121.631	122.662	1.031	6.11E+01	2.9	9.54E+00	1.3	7.81E-01 0.7
122.662	123.692	1.031	3.86E+01	2.2	6.08E+00	1.2	5.76E-01 1.0
123.692	124.723	1.031	1.94E+01	3.2	3.97E+00	1.5	4.96E-01 0.7
124.723	125.754	1.031	2.68E+01	2.6	6.27E+00	1.3	7.39E-01 0.7
125.754	126.785	1.031	4.19E+01	2.3	9.13E+00	1.3	1.07E+00 0.5
126.785	127.815	1.031	4.79E+01	2.2	1.05E+01	1.0	1.25E+00 0.5
127.815	128.846	1.031	3.88E+01	3.4	8.16E+00	1.1	1.07E+00 0.5
128.846	129.877	1.031	2.78E+01	4.3	6.45E+00	1.4	8.84E-01 0.6
129.877	130.908	1.031	1.65E+01	3.8	4.56E+00	1.8	6.47E-01 0.7
130.908	131.938	1.031	1.45E+01	4.1	3.32E+00	1.8	4.81E-01 0.8
131.938	132.969	1.031	1.99E+01	3.6	3.92E+00	1.7	4.76E-01 0.7
132.969	134.000	1.031	2.88E+01	2.9	5.91E+00	1.4	7.07E-01 0.7
134.000	135.000	1.000	3.62E+01	3.1	6.85E+00	1.4	8.05E-01 0.6
135.000	136.000	1.000	3.95E+01	2.9	8.19E+00	1.8	9.42E-01 0.6
136.000	137.000	1.000	3.64E+01	3.6	7.91E+00	1.3	1.02E+00 0.6
137.000	138.000	1.000	3.80E+01	3.4	7.43E+00	2.1	8.55E-01 0.7
138.000	139.000	1.000	2.92E+01	4.0	7.03E+00	2.0	8.20E-01 0.6
139.000	140.000	1.000	2.32E+01	6.6	5.34E+00	2.0	7.03E-01 0.8
140.000	141.000	1.000	1.95E+01	4.0	4.59E+00	1.9	5.85E-01 0.8
141.000	142.000	1.000	1.46E+01	4.3	3.68E+00	1.9	5.23E-01 0.8
142.000	143.235	1.235	1.19E+01	4.4			2.12E+00 2.4
143.235	144.469	1.235	1.01E+01	9.5			1.69E+00 2.5
144.469	145.704	1.235	1.11E+01	5.7			1.95E+00 3.6
145.704	146.939	1.235	7.11E+00	5.7			1.49E+00 2.9
146.939	148.174	1.235	7.40E+00	9.1			1.01E+00 3.0
148.174	149.408	1.235	3.81E+00	7.5			7.69E-01 3.6
149.408	150.643	1.235	3.84E+00	7.7			7.82E-01 4.9
150.643	151.878	1.235	3.48E+00	16.0			6.03E-01 5.1
151.878	153.112	1.235	1.84E+00	10.6			4.45E-01 6.4
153.112	154.347	1.235	1.28E+00	12.0			2.27E-01 6.3
154.347	155.587	1.500	8.62E-01	15.1			1.20E-01 7.7
155.587	157.347	1.500	5.67E-01	15.8			1.06E-01 14.1
157.347	159.047	1.700					6.79E+00 9.6
159.047	160.747	1.700					4.64E+00 6.8
160.747	162.247	1.500					2.26E+00 7.1
162.247	163.747	1.500					2.64E+00 7.4
163.747	165.364	1.617					2.68E+00 11.5
165.364	166.981	1.617					3.83E+00 12.7
166.982	168.599	1.617					2.52E+00 15.9

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 8 continued (3/9).

EXTRACTION Prompt dose UPWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)								
		Detector*	US1	US2	US3	US4				
108.370	109.648	1.279	1.53E-02	10.4	3.63E-05	46.7	6.59E-06	6.2	1.13E-06	14.0
109.648	110.927	1.279	2.53E-02	7.9	1.93E-04	20.4	1.76E-05	4.0	1.86E-06	9.3
110.927	112.206	1.279	5.60E-02	5.6	4.23E-04	15.1	3.61E-05	2.8	3.82E-06	7.0
112.206	113.485	1.279	9.31E-02	4.6	7.25E-04	12.8	5.18E-05	2.4	6.97E-06	5.7
113.485	114.764	1.279	1.30E-01	3.6	9.64E-04	9.0	9.14E-05	1.8	1.25E-05	4.2
114.764	116.042	1.279	2.95E-01	2.5	1.95E-03	7.7	1.61E-04	1.3	1.99E-05	3.3
116.042	117.321	1.279	4.88E-01	1.9	2.83E-03	5.6	1.92E-04	1.2	2.08E-05	3.0
117.321	118.600	1.279	9.77E-01	1.4	3.56E-03	4.9	2.39E-04	1.1	3.07E-05	2.7
118.600	119.600	1.000	8.68E-03	3.5			3.56E-04	1.0	4.81E-05	2.4
119.600	120.600	1.000	1.46E-02	2.4			5.83E-04	0.9	6.68E-05	2.0
120.600	121.631	1.031	2.21E-02	2.3			6.71E-04	0.8	8.10E-05	2.2
121.631	122.662	1.031	2.28E-02	2.8			7.04E-04	0.8	8.40E-05	2.2
122.662	123.692	1.031	1.84E-02	2.2			7.64E-04	0.8	9.13E-05	1.8
123.692	124.723	1.031	1.91E-02	2.0			7.87E-04	0.7	9.99E-05	1.8
124.723	125.754	1.031	2.66E-02	1.8			9.85E-04	0.6	1.26E-04	1.5
125.754	126.785	1.031	3.93E-02	1.5			1.40E-03	0.5	1.69E-04	1.3
126.785	127.815	1.031	4.63E-02	1.5			1.65E-03	0.5	1.93E-04	1.2
127.815	128.846	1.031	4.33E-02	1.5			1.65E-03	0.5	2.07E-04	1.2
128.846	129.877	1.031	3.56E-02	1.6			1.56E-03	0.5	2.03E-04	1.2
129.877	130.908	1.031	2.85E-02	1.9			1.28E-03	0.6	1.79E-04	1.3
130.908	131.938	1.031	2.25E-02	1.9			1.11E-03	0.6	1.53E-04	1.4
131.938	132.969	1.031	2.13E-02	2.0			9.88E-04	0.6	1.38E-04	1.5
132.969	134.000	1.031	2.60E-02	1.9			1.08E-03	0.6	1.40E-04	1.5
134.000	135.000	1.000	3.23E-02	1.7			1.33E-03	0.6	1.71E-04	1.3
135.000	136.000	1.000	3.60E-02	1.6			1.55E-03	0.5	1.99E-04	1.3
136.000	137.000	1.000	4.06E-02	1.6			1.52E-03	0.5	1.96E-04	1.2
137.000	138.000	1.000	3.76E-02	1.6			1.56E-03	0.5	2.00E-04	1.2
138.000	139.000	1.000	3.22E-02	1.7			1.47E-03	0.6	1.96E-04	1.3
139.000	140.000	1.000	3.12E-02	1.9			1.28E-03	0.6	1.76E-04	1.3
140.000	141.000	1.000	2.68E-02	2.0			1.27E-03	0.6	1.75E-04	1.3
141.000	142.000	1.000	2.51E-02	2.1			1.32E-03	0.6	1.83E-04	1.3
142.000	143.235	1.235	7.94E-01	1.1	1.50E-02	2.7	1.41E-03	0.5	1.93E-04	1.2
143.235	144.469	1.235	6.34E-01	1.1	1.61E-02	2.8	1.74E-03	0.5	2.26E-04	1.1
144.469	145.704	1.235	6.86E-01	1.5	1.51E-02	2.7	1.59E-03	0.5	2.28E-04	1.1
145.704	146.939	1.235	6.00E-01	1.3	1.59E-02	2.8	1.54E-03	0.5	2.03E-04	1.1
146.939	148.174	1.235	3.95E-01	1.8	1.17E-02	3.7	1.26E-03	0.5	1.71E-04	1.4
148.174	149.408	1.235	2.98E-01	2.0	7.65E-03	3.8	9.04E-04	0.7	1.36E-04	1.5
149.408	150.643	1.235	2.69E-01	1.8	6.93E-03	4.2	7.18E-04	0.7	1.05E-04	1.6
150.643	151.878	1.235	2.55E-01	2.3	6.68E-03	4.5	7.18E-04	0.8	1.03E-04	1.8
151.878	153.112	1.235	1.80E-01	2.5	5.26E-03	7.6	5.50E-04	0.9	8.41E-05	2.1
153.112	154.347	1.235	1.06E-01	2.6	3.86E-03	9.5	3.69E-04	1.0	5.61E-05	2.1
154.347	155.847	1.500	6.03E-02	3.0	2.69E-03	7.0	2.81E-04	1.1	4.27E-05	2.2
155.847	157.347	1.500	5.72E-02	3.1	2.06E-03	6.4	2.63E-04	1.3	3.79E-05	2.5
157.347	159.047	1.700	2.19E+00	5.7	3.15E-03	5.7	3.40E-04	1.1	4.73E-05	2.3
159.047	160.747	1.700	1.77E+00	5.5	4.07E-03	5.3	4.01E-04	1.1	5.25E-05	2.3
160.747	162.247	1.500	8.07E-01	7.0	3.38E-03	5.6	4.07E-04	1.1	5.71E-05	2.5
162.247	163.747	1.500	7.19E-01	6.9	1.75E-03	6.9	2.53E-04	1.1	3.82E-05	2.4
163.747	165.364	1.617	7.88E-01	6.1	1.88E-03	6.7	1.97E-04	1.2	3.00E-05	2.6
165.364	166.981	1.617	1.19E+00	8.7	1.91E-03	7.2	2.27E-04	1.2	3.25E-05	2.6
166.982	168.599	1.617	7.04E-01	7.8	1.56E-03	7.5	1.44E-04	1.3	1.93E-05	3.0

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 8 continued (4/9).

EXTRACTION Prompt dose DOWNWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)						
		Detector*		DC1	DCs	DC2	DC3	DC4
108.370	109.648	1.279	8.10E+01	38.5	1.97E+02	13.2	1.68E+00	12.5
109.648	110.927	1.279	6.18E+01	31.7	1.96E+02	13.3	2.44E+00	11.4
110.927	112.206	1.279	7.24E+01	35.2	2.63E+02	12.0	2.63E+00	10.9
112.206	113.485	1.279	6.07E+01	24.6	4.47E+02	10.3	2.51E+00	9.4
113.485	114.764	1.279	8.34E+01	20.0	6.04E+02	10.3	1.85E+00	10.9
114.764	116.042	1.279	1.27E+02	17.5	7.75E+02	8.3	2.65E+00	9.1
116.042	117.321	1.279	8.95E+01	19.7	1.03E+03	8.8	4.68E+00	9.7
117.321	118.600	1.279	3.03E+02	14.0	1.38E+03	7.0	2.83E+01	6.5
118.600	119.600	1.000	1.48E+03	8.0	1.33E+03	6.4	6.10E+01	5.9
119.600	120.600	1.000	4.38E+03	12.4	1.74E+03	10.5	1.12E+02	2.0
120.600	121.631	1.031	7.30E+03	8.8	1.30E+03	6.9	2.94E+02	2.1
121.631	122.662	1.031	1.58E+04	5.1	1.33E+03	21.7	7.83E+02	1.0
122.662	123.692	1.031	4.43E+04	3.4	6.14E+02	9.1	2.59E+03	3.4
123.692	124.723	1.031	1.43E+05	2.1	5.08E+02	9.8	8.94E+03	2.6
124.723	125.754	1.031	3.52E+05	1.1	8.13E+02	7.8	2.96E+04	1.5
125.754	126.785	1.031	7.25E+05	0.8	1.20E+03	7.3	6.95E+04	1.3
126.785	127.815	1.031	6.48E+05	0.8	1.57E+03	9.9	7.41E+04	1.3
127.815	128.846	1.031	4.63E+05	1.1	1.36E+03	8.3	4.83E+04	1.7
128.846	129.877	1.031	3.04E+05	1.4	1.33E+03	15.1	2.91E+04	2.3
129.877	130.908	1.031	1.85E+05	2.0	7.39E+02	10.8	1.89E+04	3.5
130.908	131.938	1.031	1.13E+05	2.2	7.95E+02	19.1	8.95E+03	4.4
131.938	132.969	1.031	8.73E+04	3.2	8.79E+02	31.6	4.95E+03	6.0
132.969	134.000	1.031	5.77E+04	3.4	1.31E+03	24.3	3.41E+03	7.0
134.000	135.000	1.000	4.89E+04	4.1	1.49E+03	16.2	2.23E+03	7.7
135.000	136.000	1.000	4.07E+04	5.2	1.15E+03	15.1	2.36E+03	13.7
136.000	137.000	1.000	1.52E+04	6.7	1.54E+03	17.3	1.34E+03	12.6
137.000	138.000	1.000	3.67E+03	11.5	1.21E+03	15.3	7.35E+02	2.0
138.000	139.000	1.000	2.53E+03	12.5	1.33E+03	24.2	3.50E+02	2.4
139.000	140.000	1.000	3.72E+03	13.3	1.39E+03	18.7	3.30E+02	2.8
140.000	141.000	1.000	4.55E+03	10.5	9.75E+02	19.7	3.12E+02	3.0
141.000	142.000	1.000	4.47E+03	10.2	9.21E+02	26.1	3.40E+02	3.0
142.000	143.235	1.235	4.49E+03	10.2	7.37E+02	20.3	3.26E+02	2.9
143.235	144.469	1.235	3.56E+03	11.5	9.34E+02	16.0	2.78E+02	3.4
144.469	145.704	1.235	2.79E+03	13.9	6.84E+02	20.8	1.73E+02	3.4
145.704	146.939	1.235	2.24E+03	17.6	9.75E+02	27.8	2.08E+02	3.8
146.939	148.174	1.235	9.76E+02	19.7	4.97E+02	20.2	1.02E+02	4.6
148.174	149.408	1.235	7.82E+02	20.9	4.67E+02	25.0	4.95E+01	3.8
149.408	150.643	1.235	7.02E+02	27.9	5.36E+02	32.9	6.90E+01	8.4
150.643	151.878	1.235	4.95E+02	23.3	4.04E+02	42.8	6.18E+01	6.8
151.878	153.112	1.235	1.30E+02	27.3	3.08E+02	29.9	2.38E+01	9.4
153.112	154.347	1.235	2.79E+02	50.5	5.43E+02	42.2	1.36E+01	6.5
154.347	155.587	1.500	1.67E+02	40.6	2.25E+02	47.8	1.04E+01	7.5
155.587	157.347	1.500	1.49E+02	31.2	2.42E+02	30.9	5.46E+00	6.6
157.347	159.047	1.700	1.32E+02	44.2	2.70E+02	26.0	3.64E+00	7.3
159.047	160.747	1.700	8.55E+01	38.5	1.60E+02	40.6	2.01E+00	8.9
160.747	162.247	1.500	8.97E+01	51.4	1.84E+02	42.1	1.59E+01	6.4
162.247	163.747	1.500	3.24E+01	61.1	1.73E+01	53.6	3.60E+00	10.7
163.747	165.364	1.617	1.26E+02	92.4	2.36E+01	56.5	3.17E+00	28.9
165.364	166.981	1.617	3.10E+01	44.1	1.19E+01	53.5	2.82E+00	11.4
166.982	168.599	1.617	1.49E+02	79.8	7.05E+00	48.2	4.58E+00	9.2

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 8 continued (5/9).

EXTRACTION Prompt dose DOWNWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)								
		Detector*		DCa	DCb	DCc	DS1			
108.370	109.648	1.279	4.91E-01	16.0	3.13E-01	4.7	5.14E-03	33.3	2.28E-03	27.8
109.648	110.927	1.279	6.24E-01	11.7	4.09E-01	4.8	2.14E-02	23.8	4.37E-03	21.6
110.927	112.206	1.279	3.80E-01	13.1	7.18E-01	3.4	1.15E-02	19.9	4.59E-03	22.0
112.206	113.485	1.279	9.60E-01	11.5	8.89E-01	2.9	1.73E-02	18.5	7.74E-03	16.3
113.485	114.764	1.279	9.08E-01	10.0	1.30E+00	2.4	3.22E-02	14.0	1.17E-02	13.8
114.764	116.042	1.279	1.47E+00	7.8	1.46E+00	2.3	5.65E-02	21.1	1.53E-02	17.6
116.042	117.321	1.279	2.82E+00	6.8	1.74E+00	2.1	5.96E-02	10.4	2.10E-02	11.1
117.321	118.600	1.279	9.36E+00	4.3	2.55E+00	1.9	1.07E-01	8.4	5.51E-02	14.8
118.600	119.600	1.000	1.13E+00	3.1	4.99E+00	2.4	6.36E-02	14.2	2.64E-02	11.1
119.600	120.600	1.000	2.36E+00	8.1	1.02E+01	5.5	1.98E-01	17.6	5.91E-02	8.1
120.600	121.631	1.031	6.05E+00	5.2	1.77E+01	3.0	3.48E-01	5.2	1.44E-01	5.3
121.631	122.662	1.031	2.23E+01	4.5	3.53E+01	2.8	7.51E-01	3.5	2.92E-01	3.3
122.662	123.692	1.031	5.55E+01	1.9	6.83E+01	1.5	1.77E+00	2.8	6.49E-01	2.3
123.692	124.723	1.031	2.03E+02	0.9	1.25E+02	1.1	3.44E+00	1.8	1.27E+00	1.6
124.723	125.754	1.031	5.90E+02	0.7	1.93E+02	0.9	5.28E+00	1.4	1.97E+00	1.3
125.754	126.785	1.031	1.06E+03	0.4	2.79E+02	0.9	7.57E+00	1.2	2.78E+00	1.1
126.785	127.815	1.031	1.32E+03	0.4	3.17E+02	0.8	9.03E+00	1.1	3.30E+00	1.0
127.815	128.846	1.031	1.05E+03	0.6	3.27E+02	0.8	9.05E+00	1.2	3.34E+00	1.0
128.846	129.877	1.031	6.27E+02	0.8	2.84E+02	1.0	8.20E+00	1.3	3.05E+00	1.1
129.877	130.908	1.031	3.09E+02	1.0	2.18E+02	1.4	6.80E+00	1.4	2.56E+00	1.3
130.908	131.938	1.031	1.60E+02	1.3	1.44E+02	1.6	4.73E+00	1.8	1.86E+00	1.6
131.938	132.969	1.031	9.87E+01	1.7	9.54E+01	1.9	2.98E+00	2.3	1.17E+00	2.0
132.969	134.000	1.031	4.83E+01	2.0	5.87E+01	2.7	1.67E+00	2.8	6.85E-01	2.5
134.000	135.000	1.000	3.90E+01	3.6	3.65E+01	3.3	9.33E-01	3.8	3.74E-01	3.2
135.000	136.000	1.000	3.64E+01	2.6	2.41E+01	3.4	6.94E-01	5.0	2.59E-01	5.4
136.000	137.000	1.000	2.48E+01	2.8	1.64E+01	3.8	3.67E-01	7.2	1.32E-01	5.0
137.000	138.000	1.000	1.72E+01	3.6	1.28E+01	4.1	2.11E-01	6.9	9.78E-02	5.9
138.000	139.000	1.000	1.09E+01	5.1	9.24E+00	4.8	1.89E-01	7.1	8.26E-02	6.4
139.000	140.000	1.000	6.52E+00	5.1	5.82E+00	5.6	1.69E-01	8.2	5.44E-02	7.2
140.000	141.000	1.000	6.53E+00	1.4	5.26E+00	1.7	1.15E-01	11.1	5.25E-02	9.2
141.000	142.000	1.000	6.17E+00	1.5	4.12E+00	1.6	1.05E-01	11.7	3.93E-02	9.0
142.000	143.235	1.235	2.70E+01	2.8	5.30E+00	1.3	4.53E-01	5.1	1.62E-01	4.2
143.235	144.469	1.235	2.45E+01	3.9	6.32E+00	1.3	6.17E-01	3.6	2.11E-01	3.6
144.469	145.704	1.235	1.70E+01	3.2	6.52E+00	1.4	6.55E-01	3.8	2.38E-01	3.6
145.704	146.939	1.235	1.28E+01	4.0	6.75E+00	1.6	6.98E-01	4.1	2.40E-01	4.3
146.939	148.174	1.235	1.27E+01	4.6	5.06E+00	1.9	5.73E-01	4.4	2.02E-01	4.3
148.174	149.408	1.235	6.40E+00	6.8	3.77E+00	1.9	4.02E-01	6.1	1.62E-01	5.1
149.408	150.643	1.235	4.04E+00	7.0	3.55E+00	3.3	3.38E-01	11.0	1.07E-01	5.7
150.643	151.878	1.235	5.14E+00	11.7	2.43E+00	2.8	2.13E-01	7.2	8.57E-02	6.3
151.878	153.112	1.235	2.63E+00	9.1	1.66E+00	3.7	1.54E-01	8.3	7.11E-02	9.2
153.112	154.347	1.235	1.19E+00	9.9	1.73E+00	5.1	1.06E-01	9.3	4.27E-02	9.6
154.347	155.847	1.500	1.30E+00	9.7	8.28E-01	3.8	9.95E-02	10.5	3.31E-02	9.5
155.847	157.347	1.500	1.18E+00	9.4	8.40E-01	5.4	5.41E-02	11.2	2.07E-02	10.8
157.347	159.047	1.700	2.31E+00	6.4	6.44E-01	3.0	4.69E-02	11.4	1.73E-02	10.9
159.047	160.747	1.700	1.30E+00	8.9	5.93E-01	3.2	6.08E-02	30.2	1.18E-02	12.3
160.747	162.247	1.500	3.46E+00	6.3	5.91E-01	3.4	3.90E-02	13.1	1.83E-02	12.8
162.247	163.747	1.500	1.34E+00	10.6	5.02E-01	3.4	3.04E-02	15.2	1.84E-02	11.0
163.747	165.364	1.617	1.26E+00	12.1	3.55E-01	3.9	3.44E-02	14.9	1.04E-02	14.1
165.364	166.981	1.617	3.56E+00	22.2	5.69E-01	4.5	5.82E-02	13.8	3.11E-02	10.7
166.982	168.599	1.617	1.27E+00	11.7	3.88E-01	7.0	2.92E-02	19.1	1.34E-02	15.4

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 8 continued (6/9).

EXTRACTION Prompt dose INWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)								
		Detector*		IC1		IC2		IC3		IC4
108.370	109.648	1.279	5.71E+02	9.3	1.45E+01	4.3	2.37E+00	8.5		
109.648	110.927	1.279	6.93E+02	7.7	2.51E+01	3.6	3.65E+00	7.1		
110.927	112.206	1.279	9.09E+02	6.9	3.60E+01	2.9	5.41E+00	5.9		
112.206	113.485	1.279	1.54E+03	20.3	4.78E+01	2.7	6.43E+00	5.6		
113.485	114.764	1.279	1.54E+03	5.5	7.48E+01	2.4	1.11E+01	4.4		
114.764	116.042	1.279	1.94E+03	6.3	8.83E+01	1.9	1.35E+01	3.8		
116.042	117.321	1.279	2.37E+03	10.1	1.28E+02	1.6	2.45E+01	3.0		
117.321	118.600	1.279	2.91E+03	9.1	1.77E+02	1.4	3.30E+01	2.5		
118.600	119.600	1.000	2.37E+03	14.5	1.78E+02	1.5	3.75E+01	2.6	1.01E+01	8.4
119.600	120.600	1.000	1.89E+03	8.4	2.18E+02	2.1	5.15E+01	3.6	1.21E+01	4.0
120.600	121.631	1.031	1.86E+03	10.4	2.10E+02	1.7	4.67E+01	2.6	1.13E+01	3.8
121.631	122.662	1.031	1.02E+03	5.0	1.72E+02	1.3	3.66E+01	2.5	1.11E+01	4.3
122.662	123.692	1.031	6.85E+02	9.0	1.48E+02	1.5	4.45E+01	2.5	1.31E+01	3.8
123.692	124.723	1.031	8.24E+02	5.9	1.96E+02	1.4	7.47E+01	2.8	2.52E+01	3.2
124.723	125.754	1.031	1.06E+03	6.9	3.14E+02	1.3	1.15E+02	1.9	3.83E+01	2.2
125.754	126.785	1.031	1.47E+03	5.2	5.04E+02	1.3	1.78E+02	1.4	5.79E+01	2.0
126.785	127.815	1.031	1.70E+03	6.2	5.71E+02	1.2	1.94E+02	1.4	6.85E+01	2.0
127.815	128.846	1.031	1.64E+03	5.5	5.44E+02	1.1	1.98E+02	1.4	7.01E+01	2.2
128.846	129.877	1.031	1.49E+03	12.6	4.53E+02	1.3	1.68E+02	1.6	5.95E+01	2.2
129.877	130.908	1.031	1.23E+03	8.6	3.23E+02	1.9	1.23E+02	2.4	4.51E+01	3.1
130.908	131.938	1.031	1.25E+03	9.7	2.79E+02	1.7	8.33E+01	2.1	2.78E+01	3.1
131.938	132.969	1.031	1.22E+03	15.2	2.28E+02	1.6	7.33E+01	2.1	2.42E+01	4.0
132.969	134.000	1.031	1.40E+03	13.1	2.24E+02	3.1	6.28E+01	4.3	2.05E+01	5.9
134.000	135.000	1.000	1.83E+03	14.2	2.27E+02	2.6	6.25E+01	2.3	2.02E+01	3.8
135.000	136.000	1.000	1.82E+03	12.9	2.76E+02	2.6	7.48E+01	3.1	2.35E+01	4.1
136.000	137.000	1.000	1.74E+03	10.1	2.54E+02	2.3	8.27E+01	4.1	2.75E+01	5.2
137.000	138.000	1.000	1.99E+03	11.1	2.72E+02	2.4	7.58E+01	3.0	2.25E+01	4.0
138.000	139.000	1.000	3.06E+03	25.9	2.60E+02	2.9	6.70E+01	4.4	2.27E+01	4.4
139.000	140.000	1.000	1.79E+03	13.8	3.51E+02	3.5	6.78E+01	3.1	2.33E+01	5.0
140.000	141.000	1.000	1.45E+03	9.8	3.04E+02	3.2	6.45E+01	4.5	1.76E+01	4.5
141.000	142.000	1.000	1.60E+03	19.2	2.34E+02	4.5	6.04E+01	4.2	2.00E+01	5.2
142.000	143.235	1.235	1.67E+03	17.2	1.65E+02	3.0	4.28E+01	3.3	1.29E+01	4.2
143.235	144.469	1.235	1.16E+03	12.7	2.50E+02	6.4	4.05E+01	5.2	1.20E+01	6.4
144.469	145.704	1.235	1.32E+03	15.0	1.76E+02	3.6	4.24E+01	13.7	1.19E+01	9.6
145.704	146.939	1.235	9.18E+02	16.0	1.69E+02	4.9	3.47E+01	6.8	8.75E+00	5.7
146.939	148.174	1.235	1.06E+03	18.8	9.27E+01	4.7	2.51E+01	5.7	7.30E+00	6.6
148.174	149.408	1.235	6.93E+02	14.8	1.30E+02	4.9	2.39E+01	6.4	6.64E+00	6.2
149.408	150.643	1.235	7.75E+02	16.9	1.17E+02	4.3	2.38E+01	7.9	5.51E+00	8.3
150.643	151.878	1.235	5.90E+02	22.3	5.54E+01	6.8	1.33E+01	10.8	3.87E+00	8.8
151.878	153.112	1.235	3.56E+02	20.6	5.26E+01	6.2	1.09E+01	6.5	2.80E+00	8.5
153.112	154.347	1.235	4.39E+02	24.7	4.45E+01	5.5	9.43E+00	7.1	2.50E+00	9.7
154.347	155.847	1.500	4.38E+02	31.0	4.52E+01	7.2	4.76E+00	11.9	1.19E+00	13.4
155.847	157.347	1.500	4.44E+02	20.8	2.20E+01	9.6	7.05E+00	15.1	1.25E+00	12.1
157.347	159.047	1.700	3.33E+02	23.2	4.85E+01	8.2	8.70E+00	10.7		
159.047	160.747	1.700	4.96E+01	33.0	2.70E+01	11.3	3.96E+00	14.6		
160.747	162.247	1.500	5.10E+01	85.7	1.03E+00	21.1	2.92E-03	86.5		
162.247	163.747	1.500	5.46E+01	68.2	1.39E+00	15.2				
163.747	165.364	1.617	1.92E+01	49.5	1.51E+00	9.9				
165.364	166.981	1.617	2.23E+01	70.5	8.25E-01	20.3				
166.982	168.599	1.617	2.56E+01	80.3	4.83E-01	27.8				

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 8 continued (7/9).

EXTRACTION Prompt dose INWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)					
		Detector* IC5	ICa	IS1	IS2		
108.370	109.648	1.279		7.69E-01	12.2	2.25E-01	7.4
109.648	110.927	1.279		1.21E+00	9.6	3.05E-01	6.2
110.927	112.206	1.279		1.78E+00	7.9	4.48E-01	5.3
112.206	113.485	1.279		2.45E+00	6.8	6.43E-01	4.4
113.485	114.764	1.279		4.08E+00	5.4	1.10E+00	3.2
114.764	116.042	1.279		5.27E+00	4.9	1.63E+00	2.7
116.042	117.321	1.279		8.78E+00	3.7	2.63E+00	2.2
117.321	118.600	1.279		1.32E+01	3.0	3.61E+00	1.8
118.600	119.600	1.000	2.79E+00	2.2	1.60E+00	2.6	5.14E-01
119.600	120.600	1.000	3.22E+00	1.7	2.02E+00	2.1	6.35E-01
120.600	121.631	1.031	3.17E+00	1.9	1.91E+00	2.2	6.41E-01
121.631	122.662	1.031	3.24E+00	1.9	2.07E+00	2.7	6.97E-01
122.662	123.692	1.031	4.58E+00	1.4	3.07E+00	2.0	1.14E+00
123.692	124.723	1.031	9.17E+00	1.5	6.10E+00	1.8	2.03E+00
124.723	125.754	1.031	1.32E+01	0.9	8.50E+00	1.1	3.03E+00
125.754	126.785	1.031	1.97E+01	0.7	1.31E+01	0.9	4.43E+00
126.785	127.815	1.031	2.36E+01	0.7	1.57E+01	0.9	5.46E+00
127.815	128.846	1.031	2.45E+01	0.7	1.62E+01	0.9	5.67E+00
128.846	129.877	1.031	2.10E+01	0.8	1.38E+01	1.0	4.82E+00
129.877	130.908	1.031	1.57E+01	0.9	1.06E+01	1.1	3.84E+00
130.908	131.938	1.031	1.01E+01	1.3	6.57E+00	1.6	2.47E+00
131.938	132.969	1.031	7.86E+00	1.2	5.21E+00	1.5	1.81E+00
132.969	134.000	1.031	6.44E+00	1.5	4.35E+00	1.7	1.59E+00
134.000	135.000	1.000	7.04E+00	1.4	4.66E+00	1.6	1.57E+00
135.000	136.000	1.000	7.40E+00	1.4	4.88E+00	1.7	1.62E+00
136.000	137.000	1.000	8.53E+00	1.5	5.71E+00	2.1	1.88E+00
137.000	138.000	1.000	8.20E+00	1.5	5.52E+00	1.9	1.85E+00
138.000	139.000	1.000	8.00E+00	1.7	5.17E+00	1.8	1.67E+00
139.000	140.000	1.000	7.38E+00	1.8	4.80E+00	3.0	1.69E+00
140.000	141.000	1.000	6.12E+00	1.9	3.92E+00	2.3	1.48E+00
141.000	142.000	1.000	5.96E+00	1.7	3.89E+00	2.0	1.37E+00
142.000	143.235	1.235		7.24E+00	1.3	2.49E+00	1.3
143.235	144.469	1.235		5.80E+00	1.5	2.07E+00	1.4
144.469	145.704	1.235		5.74E+00	1.8	1.95E+00	1.5
145.704	146.939	1.235		4.27E+00	2.1	1.62E+00	1.6
146.939	148.174	1.235		3.95E+00	2.1	1.46E+00	1.8
148.174	149.408	1.235		3.09E+00	2.2	1.20E+00	1.8
149.408	150.643	1.235		3.01E+00	2.2	8.88E-01	2.2
150.643	151.878	1.235		2.12E+00	3.7	8.34E-01	2.6
151.878	153.112	1.235		1.24E+00	2.7	5.04E-01	3.0
153.112	154.347	1.235		1.38E+00	3.1	4.49E-01	2.7
154.347	155.847	1.500		1.30E+00	5.1	1.31E-01	4.8
155.847	157.347	1.500		1.25E+00	4.0	1.66E-01	4.1
157.347	159.047	1.700		1.30E+00	3.1	4.37E-01	2.4
159.047	160.747	1.700		9.58E-01	11.6	3.08E-01	5.3
160.747	162.247	1.500		4.49E-01	21.3	1.19E-01	16.7
162.247	163.747	1.500		5.56E-01	18.7	6.10E-02	19.5
163.747	165.364	1.617		5.71E-01	12.5	1.89E-01	12.5
165.364	166.981	1.617		9.49E-02	26.4	4.36E-02	23.9
166.982	168.599	1.617		4.31E-01	17.7	1.55E-01	16.4

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 8 continued (8/9).

EXTRACTION Prompt dose OUTWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h) Error(%)						
		Detector*	OC1	OC2	OC3	OC4		
108.370	109.648	1.279	1.76E+02	18.5	2.51E+00	10.3	4.42E-01	17.3
109.648	110.927	1.279	3.30E+02	11.0	7.07E+00	9.7	1.46E+00	12.9
110.927	112.206	1.279	9.12E+02	24.3	9.83E+00	5.1	1.23E+00	11.7
112.206	113.485	1.279	9.32E+02	20.5	8.62E+00	6.3	2.31E+00	9.4
113.485	114.764	1.279	1.29E+03	12.8	2.86E+01	3.5	3.75E+00	7.9
114.764	116.042	1.279	1.79E+03	10.3	4.22E+01	2.8	7.60E+00	14.8
116.042	117.321	1.279	2.84E+03	8.4	7.56E+01	2.7	1.38E+01	4.5
117.321	118.600	1.279	5.04E+03	8.9	1.19E+02	1.7	2.35E+01	4.0
118.600	119.600	1.000	7.65E+03	7.5	2.76E+02	1.5	1.30E+02	2.0
119.600	120.600	1.000	1.26E+04	6.1	4.40E+03	8.2	3.96E+03	6.5
120.600	121.631	1.031	1.06E+04	6.6	8.33E+02	1.3	1.91E+02	1.1
121.631	122.662	1.031	1.09E+04	6.3	9.24E+02	1.1	2.39E+02	1.5
122.662	123.692	1.031	6.10E+03	7.6	4.99E+02	1.0	1.16E+02	1.7
123.692	124.723	1.031	6.75E+02	20.1	1.02E+02	2.0	3.12E+01	3.0
124.723	125.754	1.031	3.71E+02	9.7	9.15E+01	1.9	3.08E+01	2.9
125.754	126.785	1.031	4.42E+02	10.4	1.23E+02	1.8	4.39E+01	2.6
126.785	127.815	1.031	4.10E+02	9.4	1.40E+02	1.9	5.02E+01	2.5
127.815	128.846	1.031	5.43E+02	28.2	1.44E+02	2.1	5.15E+01	2.6
128.846	129.877	1.031	5.65E+02	27.6	1.24E+02	1.9	4.54E+01	3.1
129.877	130.908	1.031	3.83E+02	11.8	9.99E+01	3.1	3.46E+01	5.6
130.908	131.938	1.031	5.75E+02	28.2	9.25E+01	2.3	2.92E+01	3.6
131.938	132.969	1.031	8.07E+02	18.8	1.46E+02	5.3	3.53E+01	3.8
132.969	134.000	1.031	1.27E+03	18.5	1.47E+02	3.6	3.67E+01	2.8
134.000	135.000	1.000	1.02E+03	11.8	1.41E+02	1.9	4.32E+01	3.0
135.000	136.000	1.000	1.33E+03	23.2	1.44E+02	2.1	4.15E+01	3.3
136.000	137.000	1.000	1.54E+03	18.7	1.45E+02	2.8	4.06E+01	3.1
137.000	138.000	1.000	8.93E+02	10.0	1.58E+02	3.6	4.54E+01	3.4
138.000	139.000	1.000	9.72E+02	9.9	1.28E+02	2.5	3.77E+01	4.1
139.000	140.000	1.000	8.33E+02	11.1	1.31E+02	3.0	3.25E+01	3.6
140.000	141.000	1.000	9.35E+02	13.0	9.90E+01	3.1	2.88E+01	6.6
141.000	142.000	1.000	7.31E+02	11.9	6.42E+01	3.4	2.38E+01	5.6
142.000	143.235	1.235	6.58E+02	12.2	5.38E+01	3.1	1.67E+01	6.2
143.235	144.469	1.235	6.05E+02	14.5	4.67E+01	3.0	1.37E+01	4.7
144.469	145.704	1.235	8.83E+02	22.4	4.65E+01	4.8	1.05E+01	5.5
145.704	146.939	1.235						
146.939	148.174	1.235						
148.174	149.408	1.235						
149.408	150.643	1.235						
150.643	151.878	1.235						
151.878	153.112	1.235						
153.112	154.347	1.235						
154.347	155.847	1.500						
155.847	157.347	1.500	2.97E+02	21.5	1.78E+02	8.0	2.14E+02	7.0
157.347	159.047	1.700	3.25E+02	27.8	5.21E+01	6.5		
159.047	160.747	1.700	5.38E+01	33.1	1.81E+01	10.9		
160.747	162.247	1.500	8.24E+01	39.2	2.95E+01	10.8		
162.247	163.747	1.500	3.09E+02	63.7	2.03E+01	8.8		
163.747	165.364	1.617	6.68E+01	39.0	3.41E+01	11.1		
165.364	166.981	1.617	4.66E+01	39.9	2.55E+00	12.1		
166.982	168.599	1.617	2.56E+01	49.0	3.02E+00	9.5		

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table. 8 continued (9/9).

EXTRACTION Prompt dose OUTWARD

Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h)			Error(%)			
		Detector*	OCa	OS1	OS2			
108.370	109.648	1.279	8.66E-02	31.9	1.98E-02	11.8	2.05E-02	53.4
109.648	110.927	1.279	2.46E-01	22.0	5.14E-02	8.1	9.45E-04	29.1
110.927	112.206	1.279	2.29E-01	20.9	6.34E-02	6.5	9.81E-03	62.4
112.206	113.485	1.279	4.18E-01	17.0	9.64E-02	7.3	9.99E-05	87.7
113.485	114.764	1.279	7.03E-01	13.7	2.00E-01	6.3	1.45E-02	38.8
114.764	116.042	1.279	1.60E+00	11.9	4.90E-01	5.2	8.47E-02	22.2
116.042	117.321	1.279	2.94E+00	6.3	1.18E+00	1.9	1.60E-01	19.5
117.321	118.600	1.279	1.02E+01	5.3	6.43E+00	0.8	4.77E-01	9.6
118.600	119.600	1.000	5.20E+00	2.2	1.85E+00	1.5	2.02E-02	17.7
119.600	120.600	1.000	1.02E+01	1.1	3.33E+00	1.0	4.03E-02	12.0
120.600	121.631	1.031	1.51E+01	0.8	4.97E+00	0.8	6.37E-02	8.6
121.631	122.662	1.031	1.86E+01	0.7	5.77E+00	0.8	2.47E-01	5.0
122.662	123.692	1.031	8.70E+00	1.0	3.01E+00	1.1	5.08E-01	3.3
123.692	124.723	1.031	3.45E+00	1.6	1.32E+00	1.5	1.21E+00	2.3
124.723	125.754	1.031	3.93E+00	1.6	1.45E+00	1.5	1.95E+00	1.8
125.754	126.785	1.031	5.72E+00	1.4	2.09E+00	1.3	3.31E+00	1.5
126.785	127.815	1.031	6.41E+00	1.3	2.24E+00	1.2	3.54E+00	1.4
127.815	128.846	1.031	6.53E+00	1.4	2.23E+00	1.3	3.49E+00	1.4
128.846	129.877	1.031	5.18E+00	1.4	1.75E+00	1.4	2.95E+00	1.6
129.877	130.908	1.031	4.12E+00	1.8	1.42E+00	1.5	1.83E+00	2.1
130.908	131.938	1.031	3.61E+00	1.9	1.32E+00	1.8	9.89E-01	2.8
131.938	132.969	1.031	3.33E+00	1.8	1.17E+00	1.7	6.70E-01	3.3
132.969	134.000	1.031	3.98E+00	1.7	1.39E+00	1.6	3.53E-01	4.1
134.000	135.000	1.000	4.71E+00	1.6	1.54E+00	1.6	2.06E-01	5.7
135.000	136.000	1.000	4.42E+00	1.6	1.56E+00	1.6	1.35E-01	6.7
136.000	137.000	1.000	4.42E+00	1.6	1.45E+00	1.5	1.45E-01	6.6
137.000	138.000	1.000	4.37E+00	1.7	1.47E+00	1.6	8.54E-02	8.7
138.000	139.000	1.000	4.08E+00	1.9	1.40E+00	1.8	7.73E-02	8.8
139.000	140.000	1.000	3.25E+00	2.0	1.13E+00	1.9	9.96E-02	9.1
140.000	141.000	1.000	2.38E+00	2.3	8.79E-01	2.0	7.30E-02	10.5
141.000	142.000	1.000	2.40E+00	2.8	8.23E-01	2.3	4.38E-02	12.5
142.000	143.235	1.235	1.52E+00	2.5	5.86E-01	2.4	5.61E-01	9.0
143.235	144.469	1.235	1.23E+00	3.0	3.90E-01	3.2	5.58E-01	8.7
144.469	145.704	1.235	7.40E-01	3.6	2.83E-01	4.2	4.40E-01	14.7
145.704	146.939	1.235					5.95E-01	7.5
146.939	148.174	1.235					3.35E-01	8.0
148.174	149.408	1.235					2.00E-01	10.3
149.408	150.643	1.235					1.91E-01	9.1
150.643	151.878	1.235					1.01E-01	15.7
151.878	153.112	1.235					1.46E-01	11.5
153.112	154.347	1.235					1.10E-01	14.0
154.347	155.847	1.500					7.49E-02	16.0
155.847	157.347	1.500					1.07E-01	12.7
157.347	159.047	1.700	1.59E+01	4.5	8.33E+00	4.0	1.81E-01	17.7
159.047	160.747	1.700	5.38E+00	6.2	2.81E+00	7.0	1.12E-01	20.5
160.747	162.247	1.500	7.35E+00	7.7	3.49E+00	6.7	1.98E-02	29.0
162.247	163.747	1.500	6.37E+00	9.8	3.01E+00	6.5	8.32E-03	54.2
163.747	165.364	1.617	7.08E+00	13.5	2.00E+00	8.8	2.72E-03	63.2
165.364	166.981	1.617	3.09E+00	11.4	1.96E+00	7.5	2.70E-02	45.2
166.982	168.599	1.617	4.30E+00	13.5	1.58E+00	8.5	5.28E-02	30.6

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table 9: Prompt dose rates at the materials of beam line modules in the region from the injection through collimator. (1/2)

Location-range*	Length (m)	Module	Prompt-dose-rate(mSv/h) Error(%)							
			SUS	Iron	Ceramic	Coil	Yoke1(inner)	Yoke2	Yoke3	Yoke4(outer)
-8.349	-7.999	0.350	QUAD							
-7.999	-7.759	0.240	DRIFT	1.14E+05 26.9						
-7.759	-7.059	0.700	DRIFT	1.79E+05 11.0						
-7.059	-6.659	0.400	BUMP							
-6.659	-6.259	0.400	BUMP"							
-6.259	-5.459	0.800	SEPTUMINJ	3.75E+07 1.3	2.44E+08 1.0					
-5.459	-4.659	0.800	BUMP							
-4.659	-3.809	0.850	DRIFT	4.34E+07 2.6						
-3.809	-2.959	0.850		7.99E+06 5.5						
-2.959	-2.109	0.850		4.68E+06 7.7						
-2.109	-1.559	0.850		3.37E+06 8.8						
-1.559	-1.040	0.850	DRIFT	3.20E+06 17.5						
-1.040	-0.540	0.550	QUAD							
-0.540	-0.340	0.550	DRIFT	3.17E+06 12.8						
0.000	0.519	0.519	DRIFT	3.24E+06 12.8						
0.519	1.019	0.500	QUAD19							
1.019	1.259	0.240	DRIFT19	3.28E+05 38.9						
1.259	2.059	0.800	DRIFT	4.83E+06 8.6						
2.059	2.859	0.800	BUMP							
2.859	3.659	0.800	DRIFT	5.03E+05 23.8						
3.659	4.459	0.800	BUMP							
4.459	4.809	0.350	DRIFT	1.17E+06 25.2						
4.809	5.028	0.219	DRIFT	2.52E+06 23.2						
5.028	5.928	0.900	QUAD19							
5.928	6.840	0.912	DRIFT							
6.840	7.752	0.912		3.44E+06 10.0						
7.752	8.663	0.912		2.98E+06 10.8						
8.663	9.575	0.912		4.37E+05 22.9						
9.575	10.487	0.912	TAR1	3.37E+05 32.3						
10.487	10.637	0.150		3.01E+05 32.1						
10.637	10.887	0.250								
10.887	10.937	0.050								
10.937	11.037	0.100								
11.037	11.038	0.001								
11.038	11.137	0.099								
11.137	11.187	0.050								
11.187	11.487	0.300								
11.487	11.837	0.350								
11.837	12.837	1.000	DRIFT	2.64E+07 3.1						
12.837	12.987	0.150	COL1							
12.987	13.237	0.250								
13.237	13.287	0.050								
13.287	13.487	0.200								
13.487	13.537	0.050								
13.537	13.837	0.300								
13.837	14.187	0.350								
14.187	15.187	1.000	DRIFT	8.24E+07 1.7						
15.187	16.087	0.900	QUAD							
16.087	16.757	0.670	DRIFT	2.68E+08 1.3						
16.757	17.426	0.670		3.06E+08 1.2						
17.426	18.096	0.670		3.33E+08 1.2						
18.096	19.096	1.000	DRIFT	3.39E+08 0.9						
19.096	19.246	0.150	COL2							
19.246	19.496	0.250								
19.496	19.546	0.050								
19.546	19.746	0.200								
19.746	19.796	0.050								
19.796	20.096	0.300								
20.096	20.446	0.350								
20.446	21.446	1.000	DRIFT	3.97E+07 2.3						
21.446	22.346	0.900	QUAD19							
22.346	23.046	0.700	DRIFT	5.87E+07 2.7						
23.046	23.746	0.700	COL3	7.72E+07 2.4						
23.746	23.896	0.150								
23.896	24.146	0.250								
24.146	24.196	0.250								
24.196	24.396	0.050								
24.396	24.446	0.050								
24.446	24.746	0.300								
24.746	25.066	0.350								
25.066	25.625	0.529	DRIFT	2.35E+07 3.9						
25.625	26.155	0.530	COL4	2.60E+07 4.0						
26.155	26.305	0.150								
26.305	26.555	0.250								
26.555	26.605	0.050								
26.605	26.805	0.200								
26.805	26.855	0.050								
26.855	27.155	0.300								
27.155	27.505	0.350								
27.505	28.205	0.700	DRIFT	1.34E+07 4.7						
28.205	28.905	0.700	QUAD	1.73E+07 4.5						
28.905	29.605	0.700	DRIFT							
29.605	30.305	0.700	DRIFT	1.17E+07 5.8						
30.305	31.005	0.700	COL5	1.07E+07 6.1						
31.005	31.155	0.150								
31.155	31.405	0.250								
31.405	31.455	0.050								
31.455	31.655	0.200								
31.655	31.705	0.050								
31.705	32.005	0.300								
32.005	32.355	0.350								
32.355	33.200	0.845	DRIFT	9.93E+06 5.0						
33.200	34.046	0.845	QUAD	1.15E+07 5.3						
34.046	34.891	0.845	DRIFT	9.20E+06 6.1						
34.891	35.736	0.845	DRIFT	8.53E+06 6.6						
35.736	36.086	0.350	QUAD							
36.086	36.436	0.350	QUAD	5.68E+06 11.3	1.67E+05 40.2	4.85E+05 36.0				
36.436	38.236	1.800	RIGHT	3.71E+06 14.2	4.84E+04 60.5	1.55E+05 57.4				
38.236	41.236	3.000	BM							
41.236	42.836	1.600	LEFT	3.15E+05 23.7						
42.836	43.536	0.700	QUAD							
43.536	44.636	1.100	RIGHT	1.99E+05 41.0						
44.636	47.636	3.000	BM	5.34E+04 48.5						
47.636	49.236	1.600	LEFT							
49.236	49.936	0.700	QUAD	5.47E+05 31.4						
49.936	50.426	0.490	DRIFT	2.18E+05 41.8	1.79E+03 64.1	1.51E+04 36.1				
50.426	50.826	0.400	DRIFT	2.88E+05 42.7						
50.826	51.626	0.800	DRIFT	2.25E+05 31.2						
51.626	52.425	0.800	DRIFT	1.83E+05 43.9						
52.425	53.225	0.800	QUAD	3.45E+05 32.3						
53.225	53.725	0.500	QUAD							
53.725	54.165	0.440	DRIFT							
54.165	54.565	0.400	DRIFT							
54.565	54.985	0.420	DRIFT	3.20E+05 42.8						
54.985	55.485	0.500	QUAD							
55.485	55.974	0.489	DRIFT							
55.974	56.374	0.400	DRIFT							
56.374	57.174	0.800	DRIFT	1.13E+05 57.0						
57.174	57.974	0.800	QUAD	3.93E+03 81.7						
57.974	58.374	0.800	QUAD	8.53E+04 63.3						
58.374	59.474	0.700	QUAD							
59.474	60.574	1.000	RIGHT	5.08E+04 63.5	1.72E+03 78.8					
60.574	63.574	3.000	BM	5.17E+06 6.6	1.35E+04 22.1	4.23E+05 8.5				
63.574	66.174	1.600	LEFT	2.49E+05 24.0						
66.174	68.874	0.700	QUAD	2.12E+05 46.4	4.06E+03 78.4	2.35E+04 90.9				
68.874	69.974	0.100	RIGHT	1.44E+04 66.2						
69.974	69.974	3.000	BM	3.77E+05 23.3	1.57E+03 69.9	1.80E+04 36.6				
69.974	71.574	1.600	LEFT	6.56E+04 57.9						
71.574	71.924	0.350	QUAD							

* circumference is 348.333m

Table. 9 continued (2/2)

INJECTION Prompt dose			Prompt-dose-rate(mSv/h) Error(%)							
Location-range*	Length (m)	Module	Material Cu-Coilim	Iron1(inner)	Iron2	Iron3(outer)	Concl(inner)	Conc2	Conc3	Conc4(outer)
-8.349	-7.999	0.350	QUAD							
-7.999	-7.759	0.240	DRIFT							
-7.759	-7.059	0.700	DRIFT							
-7.059	-6.659	0.400	BUMP							
-6.659	-6.259	0.400	BUMP [*]							
-6.259	-5.459	0.800	SEPTUMINJ							
-5.459	-4.659	0.800	BUMP							
-4.659	-3.809	0.850	DRIFT							
-3.809	-2.959	0.850								
-2.959	-2.109	0.850								
-2.109	-1.259	0.850								
-1.259	-1.040	0.240	DRIFT							
-1.040	-0.540	0.500	QUAD							
-0.540	0.000	0.540	DRIFT							
0.000	0.519	0.519	DRIFT							
0.519	1.019	0.500	QUAD19							
1.019	1.259	0.240	DRIFT19							
1.259	2.059	0.800	DRIFT							
2.059	2.859	0.800	BUMP							
2.859	3.659	0.800	DRIFT							
3.659	4.459	0.800	BUMP							
4.459	4.809	0.350	DRIFT							
4.809	5.028	0.219	DRIFT							
5.028	5.928	0.900	QUAD19							
5.928	6.840	0.912	DRIFT							
6.840	7.752	0.912								
7.752	8.663	0.912								
8.663	9.575	0.912								
9.575	10.487	0.912								
10.487	10.637	0.150	TAR1							
10.637	10.887	0.250								
10.887	10.937	0.050								
10.937	11.037	0.100								
11.037	11.038	0.001								
11.038	11.137	0.099								
11.137	11.187	0.050								
11.187	11.487	0.300								
11.487	11.837	0.350								
11.837	12.837	1.000	DRIFT							
12.837	12.987	0.150	COL1							
12.987	13.237	0.250								
13.237	13.287	0.050								
13.287	13.487	0.200								
13.487	13.537	0.050								
13.537	13.837	0.300								
13.837	14.187	0.350								
14.187	15.187	1.000	DRIFT							
15.187	16.087	0.900	QUAD							
16.087	16.777	0.670	DRIFT							
16.757	16.826	0.800								
17.426	18.096	0.670								
18.096	19.096	1.000	DRIFT							
19.096	19.246	0.150	COL2							
19.246	19.496	0.250								
19.496	19.546	0.050								
19.546	19.746	0.200								
19.746	19.796	0.050								
19.796	20.096	0.300								
20.096	20.446	0.350								
20.446	21.446	1.000	DRIFT							
21.446	22.346	0.900	QUAD19							
22.346	23.046	0.700	DRIFT							
23.046	23.746	0.700								
23.746	23.896	0.150	COL3							
23.896	24.146	0.250								
24.146	24.196	0.050								
24.196	24.396	0.200								
24.396	24.446	0.050								
24.446	24.746	0.300								
24.746	25.096	0.350	DRIFT							
25.096	25.625	0.529								
25.625	26.155	0.530								
26.155	26.305	0.150	COL4							
26.305	26.555	0.250								
26.555	26.605	0.050								
26.605	26.805	0.200								
26.805	26.855	0.050								
26.855	27.155	0.300								
27.155	27.505	0.350	DRIFT							
27.505	28.205	0.700								
28.205	28.905	0.700	QUAD							
28.905	29.605	0.700	DRIFT							
29.605	30.305	0.700								
30.305	31.005	0.700								
31.005	31.155	0.150	COL5							
31.155	31.405	0.250								
31.405	31.455	0.050								
31.455	31.605	0.200								
31.605	31.705	0.050								
31.705	32.005	0.300								
32.005	32.355	0.350	DRIFT							
32.355	33.200	0.845								
33.200	34.046	0.845								
34.046	34.891	0.845								
34.891	35.736	0.845								
35.736	36.086	0.350	QUAD							
36.086	36.436	0.350	QUAD							
36.436	38.236	1.800	RIGHT							
38.236	41.236	3.000	BM							
41.236	42.836	1.600	LEFT							
42.836	43.536	0.700	QUAD							
43.536	44.636	1.100	RIGHT							
44.636	47.636	3.000	BM							
47.636	49.236	1.600	LEFT							
49.236	49.936	0.700	QUAD							
49.936	50.426	0.490	DRIFT							
50.426	50.826	0.400	DRIFT							
50.826	51.626	0.800	DRIFT							
51.626	52.425	0.800								
52.425	53.225	0.800								
53.225	53.725	0.500	QUAD							
53.725	54.165	0.440	DRIFT							
54.165	54.565	0.400	DRIFT							
54.565	54.985	0.420	DRIFT							
54.985	55.485	0.500	QUAD							
55.485	55.974	0.489	DRIFT							
55.974	56.374	0.400	DRIFT							
56.374	57.174	0.800	DRIFT							
57.174	57.974	0.800								
57.974	58.774	0.800								
58.774	59.474	0.700	QUAD							
59.474	60.574	1.100	RIGHT							
60.574	63.574	3.000	BM							
63.574	65.674	1.500	LEFT							
65.674	66.974	0.700	QUAD							
66.974	67.874	1.100	RIGHT							
67.874	69.974	3.000	BM							
69.974	71.574	1.600	LEFT							
71.574	71.924	0.350	QUAD							

* circumference is 348.333m

Table 10: Prompt dose rates at the materials of beam line modules in the region from the kicker through extraction.

EXTRACTION Prompt dose				Prompt-dose-rate(mSv/h) Error(%)									
Location-range*	Length (m)	Module	Material	SUS	Iron	Ceramic	Coil	Yoke1(inner)	Yoke2	Yoke3	Yoke4(outer)		
109.227	110.102	0.875	DRIFT	9.70E+02	33.3								
110.102	110.112	0.010	KICKER-e	8.53E+02	16.8								
110.112	110.252	0.140	KICKERd	8.82E+02	23.5								
110.252	110.952	0.700	KICKERS										
110.952	111.102	0.150	KICKERd	1.23E+03	19.8								
111.102	111.802	0.700	KICKERS										
111.802	111.952	0.150	KICKERd	2.01E+03	17.0								
111.952	112.602	0.650	KICKERS										
112.602	112.752	0.150	KICKERd	2.50E+03	14.1								
112.752	113.402	0.650	KICKERS										
113.402	113.552	0.150	KICKERd	3.11E+03	13.1								
113.552	114.202	0.650	KICKERS										
114.202	114.342	0.140	KICKERd	3.08E+03	23.6								
114.342	114.352	0.010	KICKER-e	3.54E+03	24.0								
114.352	114.852	0.500	DRIFT	2.76E+03	24.9								
114.852	115.071	0.219	DRIFT	4.42E+03	39.0								
115.071	115.571	0.500	QUAD										
115.571	116.111	0.540	DRIFT	3.68E+03	14.4								2.82E+03 25.9
116.111	116.630	0.519	DRIFT	5.19E+03	26.3								4.32E+03 24.2
116.630	117.130	0.500	QUAD										
117.130	117.370	0.240	DRIFT	6.58E+03	25.6								
117.370	117.870	0.500	DRIFT	6.04E+03	17.8								
117.870	117.880	0.010	KICKER-e	6.76E+03	6.9								
117.880	118.020	0.140	KICKERd	6.46E+03	9.0								
118.020	118.720	0.700	KICKERS										
118.720	118.870	0.150	KICKERd	7.94E+03	8.1								
118.870	119.570	0.700	KICKERS										
119.570	119.720	0.150	KICKERd	1.64E+04	32.8								
119.720	120.370	0.650	KICKERS										
120.370	120.510	0.140	KICKERd	1.30E+04	7.1								
120.510	120.520	0.010	KICKER-e	1.63E+04	9.5								
120.520	120.920	0.240	DRIFT	1.02E+05	70.7								
120.920	121.139	0.500	DRIFT	3.83E+04	34.6								
121.139	122.399	0.300	QUAD										
122.039	122.279	0.240	DRIFT	9.81E+04	13.5								
122.279	123.029	0.750	DRIFT	1.32E+05	11.7								
123.029	123.779	0.750		3.03E+05	10.2								
123.779	124.529	0.750		9.58E+05	4.5								
124.529	125.279	0.750		1.87E+07	1.3								
125.279	126.179	0.900	SEPTUMA	7.94E+07	0.5	8.19E+08 0.4							
126.179	126.679	0.500	DRIFT	3.26E+07	1.4								
126.679	127.579	0.900	SEPTUMB	1.01E+07	1.6	1.90E+07 2.5							
127.579	128.279	0.700	DRIFT	4.44E+06	3.3								
128.279	129.179	0.900	SEPTUMC	3.26E+06	3.6	1.35E+06 6.0							
129.179	129.679	0.500	DRIFT	1.99E+06	5.9								
129.679	130.579	0.900	SEPTUMD	2.32E+06	4.6	4.59E+05 6.1							
130.579	131.079	0.500	DRIFT	1.37E+06	7.8								
131.079	131.298	0.219	DRIFT	1.64E+06	8.7								
131.298	132.198	0.900	QUAD										
132.198	133.091	0.893	DRIFT	1.37E+06	6.3								1.32E+05 13.1
133.091	133.984	0.893		1.21E+06	7.0								
133.984	134.878	0.893		8.96E+05	8.1								
134.878	135.771	0.893		8.45E+05	8.1								
135.771	136.664	0.893		9.75E+05	7.9								
136.664	137.557	0.893		8.36E+05	8.7								
137.557	138.457	0.900	QUAD										
138.457	139.394	0.937	DRIFT	5.55E+05	9.4								1.10E+04 32.1
139.394	140.331	0.937		3.11E+05	11.5								
140.331	141.268	0.937		3.68E+05	13.5								
141.268	142.205	0.937		2.47E+05	15.6								
142.205	143.142	0.937		2.43E+05	15.7								
143.142	144.079	0.937		2.01E+05	16.5								
144.079	145.016	0.937		1.57E+05	20.0								
145.016	145.716	0.700	QUAD										
146.516	146.592	0.876	DRIFT	2.74E+04	34.7								7.26E+03 34.0
146.592	147.468	0.876		1.89E+04	48.8								
147.468	148.344	0.876		1.48E+04	44.3								
148.344	149.219	0.876		1.54E+04	56.5								
149.219	150.065	0.876		5.52E+03	52.1								
150.065	150.871	0.876		7.90E+03	58.1								
150.871	151.847	0.876		7.93E+03	53.7								
151.847	152.197	0.350	QUAD										
152.197	152.547	0.350	QUAD	5.76E+03	77.0	6.79E+03 51.9							5.44E+03 55.1
152.547	154.347	1.800	RIGHT	2.82E+03	91.9								8.68E+02 72.4
154.347	157.347	3.000	BM										
157.347	158.947	1.600	LEFT	8.51E+03	57.3								
158.947	159.647	0.700	QUAD										
159.647	160.747	1.100	RIGHT	8.76E+02	87.2								
160.747	163.747	3.000	BM										
163.747	165.347	1.600	LEFT	4.02E+02	83.6								
165.347	166.047	0.700	QUAD										
166.047	166.537	0.490	DRIFT	2.97E+01	100.0								
166.537	166.937	0.400	DRIFT	1.60E+02	74.8								
166.937	167.737	0.800	DRIFT	2.65E+01	100.0								
167.737	168.536	0.800		2.09E+03	87.8								
168.536	169.336	0.800		4.01E+02	70.7								
169.336	169.836	0.500	QUAD										2.11E+02 95.5

* circumference is 348.333m

Table 11: Prompt dose rates at the local shields in the collimator region, the injection septum region, and the extraction septum region

COLLIMATOR Prompt dose		Length (m)	Prompt-dose-rate(mSv/h) Error(%)						
Location-range (m)			Detector						
			ConL1		ironL		ConL2		
11.944	12.644	0.700	1.65E+05	4.1	3.31E+04	5.5	1.37E+04	7.0	
14.248	14.948	0.700	5.19E+05	2.6	1.35E+05	3.5	5.46E+04	4.1	
16.894	17.594	0.700	1.45E+06	1.8	3.11E+05	2.2	8.03E+04	3.4	
17.594	18.294	0.700	1.79E+06	1.7	3.74E+05	2.1	5.30E+04	3.8	
18.294	18.894	0.600	2.07E+06	1.6	4.61E+05	2.0	8.00E+04	3.2	
20.497	21.197	0.700	4.37E+05	2.8	1.12E+05	4.1	5.72E+04	3.7	
23.028	23.728	0.700	4.30E+05	3.3	6.93E+04	4.6	2.56E+04	5.2	
25.308	26.008	0.700	2.59E+05	3.9	6.13E+04	5.7	2.61E+04	5.8	
27.556	28.056	0.500	8.26E+04	7.1	2.07E+04	11.3	1.19E+04	9.0	
29.978	30.678	0.700	7.51E+04	7.4	1.56E+04	9.4	7.28E+03	10.0	
33.155	33.955	0.800	2.05E+05	4.5			1.79E+04	7.1	

INJECTION Prompt dose									
Location-range (m)	Length (m)	Prompt-dose-rate(mSv/h)				Error(%)			
		Detector							
		ConL1		ironL		ConL2			
-7.559	-6.526	1.033	1.35E+05	1.7	1.22E+04	4.6	7.27E+02	17.4	
-6.526	-5.492	1.033	4.03E+05	1.2	5.84E+04	2.5	3.37E+03	9.4	
-5.492	-4.459	1.033	4.33E+05	1.2	9.06E+04	2.3	9.29E+03	6.6	
-4.459	-3.659	0.800	4.33E+06	0.7	3.91E+05	1.0	3.58E+04	2.9	

EXTRACTION Prompt dose											
Location-range (m)		Length (m)	Prompt-dose-rate(mSv/h) Error(%)								
			Detector		ConL1			ironL		ConL2	
124.779	126.354	1.575	1.60E+06	0.3	1.89E+05	0.5	1.52E+04	1.5	2.27E+04	1.9	
126.354	127.929	1.575	1.11E+06	0.4	1.91E+05	0.6	1.64E+04	1.7	2.67E+04	2.0	
127.929	129.504	1.575	3.26E+05	0.9	5.81E+04	1.2	4.80E+03	3.3	8.73E+03	3.6	
129.504	131.079	1.575	1.08E+05	1.9	1.59E+04	2.3	1.45E+03	4.6	2.90E+03	5.9	

INJECTION

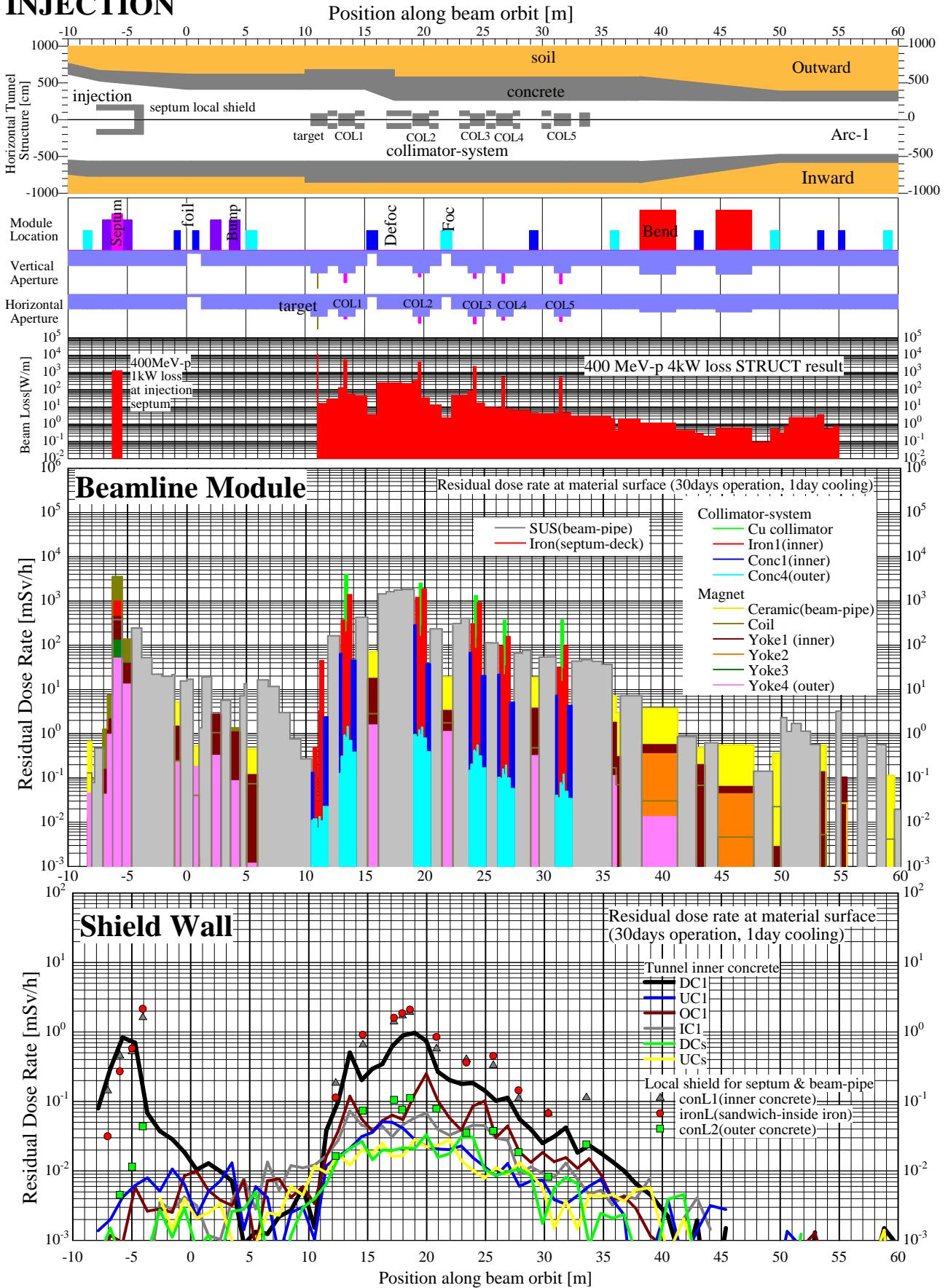


Figure 46: Calculated residual dose rate distributions at the surfaces of the machine modules, local shields and tunnel walls in the region from injection through collimator.

EXTRACTION

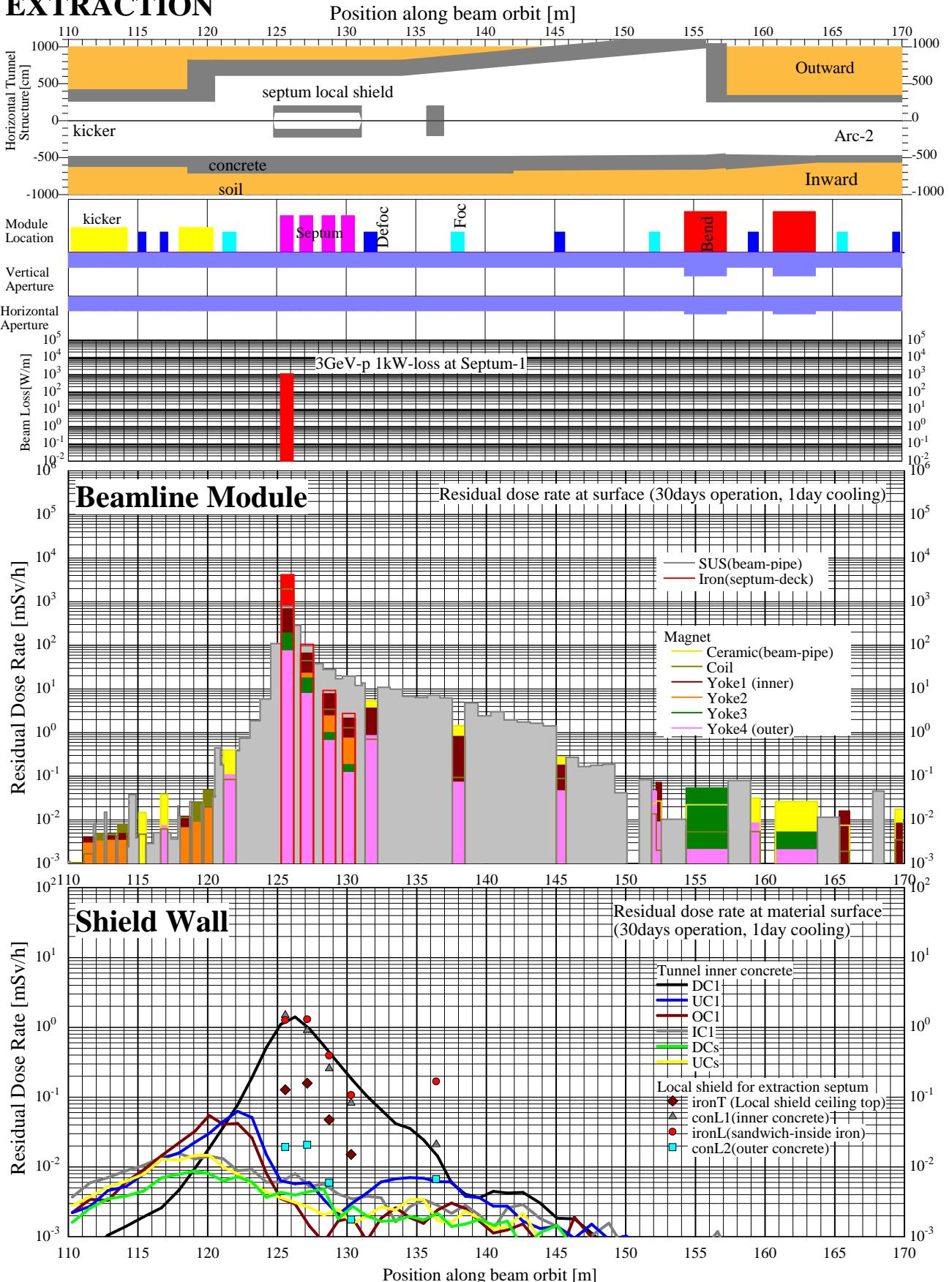


Figure 47: Calculated residual dose rate distributions at the surfaces of the machine modules, local shields and tunnel walls in the region from kicker through extraction.

Table 12: Residual dose rates inside the concrete shield wall of tunnel in the region from the injection through collimator.

INJECTION Residual dose		Length (m)	Residual-dose-rate(mSv/h) Error(%)							
Location-range (m)	Detector*		UC1	UCs	DC1	DCs	IC1	OC1		
-8.349	-7.349	1.000	1.38E-03	34.0	3.30E-04	60.0	7.94E-02	10.7	5.64E-04	100.0
-7.349	-6.299	1.050	2.00E-03	19.2	4.60E-04	57.7	2.98E-01	6.2	1.50E-03	92.1
-6.299	-5.249	1.050	4.18E-03	42.9	1.13E-04	68.9	8.34E-01	4.2	4.80E-04	100.0
-5.249	-4.199	1.050	6.19E-03	44.9	3.79E-04	70.1	6.99E-01	4.7	3.05E-04	83.9
-4.199	-3.150	1.050	7.94E-03	60.1	0.00E+00	0.0	6.80E-02	19.1	6.29E-04	55.6
-3.150	-2.100	1.050	5.12E-03	17.4	4.06E-03	60.1	3.74E-02	27.2	2.75E-03	29.3
-2.100	-1.050	1.050	1.06E-02	53.3	1.47E-03	50.6	2.87E-02	26.8	1.12E-03	45.3
-1.050	0.000	1.050	6.37E-03	47.0	3.95E-03	27.2	1.85E-02	26.6	2.92E-03	42.0
0.000	1.000	1.000	2.25E-03	30.5	2.10E-03	70.9	1.04E-02	31.9	7.25E-04	47.1
1.000	2.000	1.000	5.08E-03	59.2	2.49E-03	22.0	1.29E-02	30.4	1.18E-03	72.9
2.000	3.000	1.000	7.20E-03	63.6	3.39E-03	51.1	9.89E-03	59.6	5.74E-04	50.7
3.000	4.000	1.000	1.30E-02	35.6	1.00E-03	57.9	7.12E-03	11.4	2.61E-03	30.3
4.000	5.000	1.000	1.44E-03	35.9	6.57E-04	43.7	8.84E-04	33.6	2.81E-03	46.2
5.000	6.000	1.000	5.94E-03	38.1	8.73E-04	62.9	1.32E-03	32.8	5.00E-03	43.6
6.000	7.000	1.000	4.14E-03	51.3	2.52E-03	61.5	1.25E-03	55.5	5.74E-04	51.4
7.000	8.000	1.000	6.01E-04	43.2	2.30E-03	13.1	2.21E-03	32.5	2.46E-04	60.6
8.000	9.000	1.000	2.52E-03	18.2	6.01E-03	73.2	2.72E-03	38.7	1.18E-03	45.0
9.000	10.000	1.000	3.05E-03	50.2	4.48E-03	27.6	5.70E-03	19.6	2.97E-03	37.5
10.000	11.000	1.000	1.04E-03	30.6	1.18E-02	42.1	1.54E-03	30.8	3.98E-03	19.6
11.000	12.000	1.000	1.18E-02	38.7	9.44E-03	33.7	3.82E-02	8.3	6.54E-03	21.4
12.000	13.000	1.000	1.62E-02	29.1	1.76E-02	41.6	1.00E-01	13.0	1.52E-02	39.6
13.000	14.000	1.000	2.11E-02	26.2	1.22E-02	11.7	5.06E-01	5.9	2.09E-02	12.4
14.000	15.000	1.000	3.12E-02	25.2	2.01E-02	27.5	2.03E-01	9.7	2.68E-02	18.1
15.000	15.833	0.833	3.60E-02	16.4	1.81E-02	31.0	2.96E-01	8.9	1.45E-02	37.1
15.833	16.667	0.833	5.08E-02	20.6	2.50E-02	24.6	3.45E-01	7.2	2.00E-02	45.1
16.667	17.500	0.833	5.01E-02	36.5	1.64E-02	34.2	6.24E-01	6.3	1.97E-02	67.3
17.500	18.487	0.987	4.13E-02	20.5	1.66E-02	28.7	8.88E-01	4.3	2.15E-02	28.3
18.487	19.475	0.987	2.84E-02	20.4	2.84E-02	29.0	9.73E-01	4.6	2.09E-02	24.5
19.475	20.462	0.987	2.26E-02	21.3	2.22E-02	45.8	7.43E-01	5.2	3.32E-02	20.9
20.462	21.450	0.987	2.07E-02	31.2	2.32E-02	27.5	2.68E-01	8.3	1.58E-02	29.9
21.450	22.437	0.987	2.03E-02	31.9	2.82E-02	27.3	2.05E-01	9.2	1.77E-02	36.5
22.437	23.425	0.987	2.28E-02	31.4	1.43E-02	31.5	1.79E-01	10.4	3.07E-02	36.7
23.425	24.412	0.987	1.56E-02	24.0	1.02E-02	22.1	1.84E-01	10.5	3.09E-02	42.4
24.412	25.399	0.987	1.15E-02	52.0	7.93E-03	30.1	1.45E-01	10.9	1.06E-02	42.4
25.399	26.387	0.987	8.50E-03	16.4	1.11E-02	32.9	1.02E-01	14.4	8.57E-03	52.7
26.387	27.374	0.987	1.28E-02	58.2	8.92E-03	42.4	1.13E-01	14.5	9.68E-03	54.2
27.374	28.362	0.987	6.03E-03	31.2	1.31E-02	45.3	5.58E-02	21.5	1.06E-02	41.0
28.362	29.349	0.987	7.20E-03	42.6	9.05E-03	65.8	3.97E-02	18.4	8.66E-03	53.6
29.349	30.337	0.987	7.37E-03	60.4	5.80E-03	52.7	2.51E-02	26.3	1.76E-03	36.4
30.337	31.324	0.987	3.86E-03	15.8	1.50E-03	46.1	3.13E-02	26.8	5.63E-03	53.9
31.324	32.311	0.987	3.33E-03	49.6	3.73E-03	44.6	4.22E-02	17.7	8.07E-03	78.6
32.311	33.299	0.987	4.41E-03	11.8	1.46E-03	78.0	1.84E-02	26.8	6.54E-03	71.9
33.299	34.286	0.987	6.04E-03	31.6	4.51E-03	66.7	2.34E-02	43.7	8.53E-04	55.0
34.286	35.274	0.987	7.61E-03	30.1	4.31E-03	69.3	1.80E-02	41.2	2.44E-03	62.8
35.274	36.261	0.987	3.87E-03	18.9	4.55E-03	1.9	1.35E-02	40.8	2.09E-03	41.4
36.261	37.249	0.987	2.33E-03	15.4	3.67E-03	73.2	1.00E-02	38.1	2.35E-03	67.1
37.249	38.236	0.987	8.06E-05	62.1	5.39E-03	82.3	6.56E-03	40.1	6.55E-04	55.3
38.236	39.736	1.500	5.12E-04	50.2	5.70E-03	61.8	4.54E-03	48.0	2.51E-04	52.2
39.736	41.236	1.500	3.76E-03	79.7	6.36E-04	76.5	2.21E-03	89.9	3.90E-03	69.1
41.236	42.369	1.133	4.89E-04	62.3	2.04E-03	66.4	3.46E-04	67.1	4.58E-03	60.3
42.369	43.503	1.133	1.38E-03	4.8	5.43E-04	75.2	1.94E-03	23.7	3.57E-04	85.8
43.503	44.636	1.133	3.18E-03	82.5	3.13E-05	100.0	6.26E-05	100.0	1.42E-04	100.0
44.636	46.136	1.500	2.78E-03	71.3	0.00E+00	0.0	1.51E-03	67.6	0.00E+00	0.0
46.136	47.636	1.500	0.00E+00	0.0	1.45E-04	98.8	0.00E+00	0.0	0.00E+00	0.0
47.636	48.818	1.182	2.26E-07	70.8	1.70E-04	100.0	0.00E+00	0.0	1.34E-03	8.7
48.818	50.000	1.182	1.44E-04	100.0	0.00E+00	0.0	1.83E-04	95.8	0.00E+00	0.0
50.000	51.175	1.175	1.35E-03	8.5	5.41E-04	100.0	3.38E-04	71.5	9.76E-05	100.0
51.175	52.350	1.175	8.14E-04	74.8	0.00E+00	0.0	1.34E-05	93.8	1.23E-03	0.0
52.350	53.525	1.175	4.44E-05	90.8	0.00E+00	0.0	1.30E-03	94.0	0.00E+00	0.0
53.525	54.700	1.175	1.82E-04	84.3	0.00E+00	0.0	0.00E+00	0.0	0.00E+00	0.0
54.700	55.874	1.175	0.00E+00	0.0	2.76E-04	100.0	0.00E+00	0.0	4.08E-05	100.0
55.874	57.049	1.175	4.11E-04	81.4	5.66E-04	97.9	0.00E+00	0.0	4.88E-05	100.0
57.049	58.224	1.175	3.43E-04	79.0	3.74E-04	100.0	2.59E-04	100.0	3.16E-05	100.0
58.224	59.399	1.175	3.88E-04	71.2	1.40E-03	9.6	1.49E-03	35.7	0.00E+00	0.0
59.399	60.574	1.175	8.36E-04	61.1	7.28E-06	100.0	8.32E-04	34.2	0.00E+00	0.0
60.574	62.074	1.500	1.90E-04	100.0	2.23E-04	100.0	4.52E-05	82.6	0.00E+00	0.0
62.074	63.574	1.500	4.69E-04	100.0	0.00E+00	0.0	1.77E-03	63.1	1.71E-03	88.3
63.574	64.707	1.133	0.00E+00	0.0	0.00E+00	0.0	2.21E-04	100.0	0.00E+00	0.0
64.707	65.841	1.133	0.00E+00	0.0	0.00E+00	0.0	1.72E-04	100.0	0.00E+00	0.0
65.841	66.974	1.133	0.00E+00	0.0	0.00E+00	0.0	0.00E+00	0.0	0.00E+00	0.0
66.974	68.474	1.500	0.00E+00	0.0	0.00E+00	0.0	7.50E-05	100.0	1.04E-04	100.0
68.474	69.974	1.500	0.00E+00	0.0	0.00E+00	0.0	0.00E+00	0.0	0.00E+00	0.0
69.974	71.341	1.367	0.00E+00	0.0	0.00E+00	0.0	5.69E-04	100.0	0.00E+00	0.0

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table 13: Residual dose rates inside the concrete shield wall of tunnel in the region from the kicker through extraction.

EXTRACTION Residual dose		Location-range (m)	Length (m)	Residual-dose-rate(mSv/h) Error(%)										
Detector*	UC1	UCs	DC1	DCs	IC1	OC1								
109.648	110.927	1.279	2.21E-03	23.0	2.81E-03	19.3	7.50E-04	15.6	1.61E-03	12.1	3.69E-03	18.0	2.22E-03	20.5
110.927	112.206	1.279	2.72E-03	27.1	3.75E-03	23.6	6.11E-04	13.1	2.57E-03	20.5	5.94E-03	15.6	3.43E-03	21.8
112.206	113.485	1.279	4.59E-03	20.6	5.16E-03	13.1	1.06E-03	10.0	3.50E-03	19.0	7.05E-03	12.4	3.31E-03	14.9
113.485	114.764	1.279	5.23E-03	16.6	6.22E-03	11.6	1.41E-03	12.4	3.81E-03	15.9	8.79E-03	14.1	6.06E-03	14.9
114.764	116.042	1.279	7.87E-03	11.4	7.92E-03	12.2	1.93E-03	16.7	4.53E-03	17.8	1.06E-02	10.0	9.10E-03	11.4
116.042	117.321	1.279	1.31E-02	10.6	1.30E-02	10.4	2.59E-03	23.6	6.99E-03	9.9	1.39E-02	9.2	1.45E-02	10.3
117.321	118.600	1.279	1.60E-02	10.4	1.25E-02	8.0	4.67E-03	11.8	7.86E-03	11.5	1.55E-02	8.2	2.23E-02	6.9
118.600	119.600	1.000	2.27E-02	8.9	1.46E-02	9.6	9.65E-03	9.7	8.72E-03	9.4	1.30E-02	9.5	3.26E-02	6.7
119.600	120.600	1.000	3.02E-02	6.6	1.47E-02	9.4	1.86E-02	9.2	8.01E-03	12.0	1.43E-02	10.0	5.47E-02	5.3
120.600	121.631	1.031	4.50E-02	5.7	9.98E-03	10.8	3.71E-02	6.5	6.32E-03	13.1	1.31E-02	9.3	4.07E-02	5.5
121.631	122.662	1.031	6.28E-02	4.5	7.96E-03	8.8	7.78E-02	4.8	7.22E-03	13.1	8.85E-03	13.9	4.21E-02	5.1
122.662	123.692	1.031	5.11E-02	4.7	5.72E-03	16.4	1.92E-01	3.1	6.08E-03	15.0	9.12E-03	10.1	2.61E-02	6.7
123.692	124.723	1.031	1.50E-02	6.9	4.37E-03	14.5	5.16E-01	1.7	3.68E-03	15.6	6.07E-03	11.4	8.10E-03	10.7
124.723	125.754	1.031	6.32E-03	9.3	3.61E-03	10.1	1.10E+00	1.1	4.32E-03	16.6	6.05E-03	11.6	3.51E-03	17.3
125.754	126.785	1.031	5.75E-03	13.2	3.09E-03	15.6	1.41E+00	1.0	3.94E-03	16.3	8.06E-03	15.1	2.94E-03	18.9
126.785	127.815	1.031	5.96E-03	15.0	2.64E-03	21.0	9.52E-01	1.4	4.45E-03	19.5	5.27E-03	16.4	1.43E-03	10.1
127.815	128.846	1.031	3.41E-03	20.3	2.04E-03	31.8	5.48E-01	1.9	4.81E-03	24.2	5.69E-03	17.0	8.32E-04	29.2
128.846	129.877	1.031	2.08E-03	24.3	2.46E-03	22.8	3.07E-01	2.7	1.81E-03	27.9	4.09E-03	19.8	1.68E-03	21.9
129.877	130.908	1.031	3.06E-03	26.8	1.55E-03	23.0	1.76E-01	3.4	2.73E-03	25.3	3.47E-03	19.3	1.87E-03	25.7
130.908	131.938	1.031	4.24E-03	18.9	1.98E-03	38.7	1.04E-01	4.3	1.98E-03	33.5	3.79E-03	22.5	8.75E-04	18.5
131.938	132.969	1.031	6.09E-03	16.9	2.65E-03	19.8	6.60E-02	6.0	1.66E-03	21.8	3.63E-03	20.0	1.84E-03	26.5
132.969	134.000	1.031	6.74E-03	15.0	2.42E-03	25.5	4.18E-02	7.2	1.71E-03	29.5	1.64E-03	22.8	2.60E-03	23.1
134.000	135.000	1.000	7.05E-03	15.1	3.43E-03	20.5	3.58E-02	8.1	1.95E-03	28.2	2.68E-03	27.3	1.88E-03	20.1
135.000	136.000	1.000	6.90E-03	19.2	3.41E-03	18.4	2.45E-02	9.4	1.75E-03	27.8	3.41E-03	27.3	1.55E-03	27.8
136.000	137.000	1.000	6.14E-03	13.4	1.69E-03	35.6	1.43E-02	13.3	2.17E-03	31.9	2.82E-03	20.9	2.42E-03	28.7
137.000	138.000	1.000	6.12E-03	16.8	1.61E-03	31.8	5.95E-03	16.0	1.40E-03	25.1	2.16E-03	25.7	3.04E-03	22.4
138.000	139.000	1.000	3.81E-03	31.3	2.32E-03	25.1	4.08E-03	19.9	1.52E-03	29.0	2.82E-03	21.4	2.54E-03	26.4
139.000	140.000	1.000	3.62E-03	25.0	1.83E-03	42.5	3.63E-03	21.4	1.77E-03	43.5	2.04E-03	25.4	1.67E-03	27.4
140.000	141.000	1.000	2.74E-03	20.4	1.31E-03	45.4	4.48E-03	19.1	1.47E-03	42.7	1.30E-03	32.9	1.13E-03	38.0
141.000	142.000	1.000	2.74E-03	24.6	1.38E-03	41.3	4.23E-03	27.9	1.68E-03	45.9	2.58E-03	24.2	1.25E-03	34.8
142.000	143.235	1.235	1.67E-03	31.0	2.19E-03	29.3	4.32E-03	20.1	6.82E-04	56.6	2.89E-03	21.4	1.53E-03	28.0
143.235	144.469	1.235	1.31E-03	24.8	9.10E-04	34.2	3.05E-03	28.0	1.14E-03	38.9	1.83E-03	29.1	7.60E-04	33.1
144.469	145.704	1.235	1.41E-03	32.9	9.68E-04	68.6	1.84E-03	22.4	1.45E-03	29.5	1.41E-03	29.3	4.74E-04	60.4
145.704	146.939	1.235	9.52E-04	47.7	7.78E-04	34.1	1.81E-03	27.3	6.69E-04	70.9	8.19E-04	35.3	1.90E-03	32.1
146.939	148.174	1.235	1.51E-03	45.9	7.83E-04	16.0	1.12E-03	45.2	6.76E-04	50.0	1.04E-03	28.1	9.79E-04	40.9
148.174	149.408	1.235	9.22E-04	34.6	4.46E-04	37.7	6.81E-04	35.7	3.42E-04	36.8	1.56E-03	31.9	3.91E-04	9.9
149.408	150.643	1.235	1.03E-03	39.7	2.49E-04	28.4	4.15E-04	20.9	2.56E-04	45.9	6.16E-04	38.2	5.48E-04	42.0
150.643	151.878	1.235	7.40E-04	41.2	9.55E-04	34.7	2.43E-04	20.1	1.94E-04	55.1	5.59E-04	49.0	6.77E-05	41.0
151.878	153.112	1.235	3.61E-04	40.7	2.90E-04	48.6	3.70E-04	76.8	4.11E-04	91.6	9.79E-04	40.6	4.17E-05	54.3
153.112	154.347	1.235	5.72E-05	43.1	5.51E-04	50.1	4.93E-04	71.1	1.74E-05	71.9	5.68E-04	40.7	5.52E-04	58.9
154.347	155.847	1.500	7.33E-05	54.0	1.65E-04	72.8	7.79E-05	99.1	1.48E-04	41.5	5.13E-04	58.8	2.95E-04	38.2
155.847	157.347	1.500	1.71E-04	52.2	9.53E-04	65.4	1.26E-04	65.7	7.47E-04	56.5	1.18E-03	69.2	1.23E-04	84.0
157.347	159.047	1.700	1.22E-04	60.3	3.91E-04	53.9	6.95E-05	41.0	1.30E-04	55.5	2.50E-04	40.9	3.33E-04	62.8
159.047	160.747	1.700	1.62E-04	84.8	1.84E-04	13.7	1.15E-04	41.6	1.75E-04	79.9	3.80E-05	52.2	2.43E-04	76.9
160.747	162.247	1.500	2.34E-05	100.0	4.75E-05	63.5	3.98E-05	57.7	2.25E-04	100.0	9.74E-06	78.6	1.79E-04	72.2
162.247	163.747	1.500	0.00E+00	0.0	0.00E+00	0.0	9.29E-05	14.9	1.18E-04	100.0	1.33E-04	100.0	2.67E-05	84.2
163.747	165.364	1.617	4.23E-05	99.7	1.71E-04	28.2	1.40E-04	60.2	7.43E-05	53.6	8.03E-06	100.0	2.66E-05	78.0
165.364	166.981	1.617	3.41E-05	99.2	1.08E-06	74.9	0.00E+00	0.0	2.73E-04	81.6	0.00E+00	0.0	2.82E-05	100.0
166.982	168.599	1.617	8.39E-05	86.7	9.81E-05	21.1	4.42E-05	56.6	2.16E-05	67.2	4.16E-05	71.5	0.00E+00	0.0

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table 14: Residual dose rates at the materials of beam line modules in the region from the injection through collimator. (1/2)

INJECTION Residual dose			Residual-dose-rate(mSv/h) Error(%)															
Location-range*	Length (m)	Module	Material		SUS	Iron	Ceramic	Coil	Yoke1(inner)	Yoke2	Yoke3	Yoke4(outer)						
-8.349	-7.999	0.350	QUAD		7.94E-02	24.3			6.67E-01	19.3	1.31E-01	25.1	1.21E-02	29.8				
-7.999	-7.759	0.240	DRIFT		4.70E-01	2.2												
-7.759	-7.059	0.700	DRIFT						1.27E+00	8.5	1.54E-01	1.1			4.26E-02	54.4		
-7.059	-6.659	0.400	BUMP						7.42E+00	3.6	2.12E+00	21.6			9.63E-01	27.0		
-6.659	-6.259	0.400	BUMP						3.53E+03	0.7	4.38E+02	1.4			5.07E+01	5.0		
-6.259	-5.459	0.800	SEPTUMINJ		3.77E+02	1.7	9.89E+02	2.5			1.36E+02	2.5	3.88E+01	2.5		1.32E+01	3.4	
-5.459	-4.659	0.800	BUMP															
-4.659	-3.809	0.850	DRIFT			2.45E+02	2.6											
-3.809	-2.959	0.850				5.21E+01	5.5											
-2.959	-2.109	0.850				2.22E+01	8.1											
-2.109	-1.259	0.850				1.99E+01	8.5											
-1.259	-1.040	0.219	DRIFT			2.18E+01	16.8											
-1.040	-0.540	0.500	QUAD						5.15E+00	15.7	2.42E-01	36.6	1.47E+00	65.0		2.38E-01	79.7	
-0.540	0.000	0.540	DRIFT			1.56E+01	12.5											
0.000	0.519	0.519	DRIFT			1.70E+01	11.9											
0.519	1.019	0.500	QUAD19						5.29E-01	32.9	4.03E-02	47.2	1.58E-03	50.2		1.80E-01	96.4	
1.019	1.259	0.240	DRIFT19			1.35E+00	64.3											
1.259	2.059	0.800	DRIFT			1.93E+01	8.8											
2.059	2.859	0.800	BUMP															
2.859	3.659	0.800	DRIFT			5.69E+00	20.5											
3.659	4.459	0.800	BUMP															
4.459	4.809	0.350	DRIFT			7.15E+00	22.3											
4.809	5.028	0.219	DRIFT			1.35E+01	19.4											
5.028	5.928	0.900	QUAD19						4.51E-01	24.2	7.38E-02	52.3	1.18E-01	95.1		1.17E-03	45.7	
5.928	6.840	0.912	DRIFT			1.64E+01	9.8											
6.840	7.752	0.912				1.17E+01	10.6											
7.752	8.663	0.912				2.99E+00	21.5											
8.663	9.575	0.912				7.62E-01	44.6											
9.575	10.487	0.912				2.71E-01	59.3											
10.487	10.637	0.150	TAR1															
10.637	10.887	0.250																
10.887	10.937	0.050																
10.937	11.037	0.100																
11.037	11.038	0.001																
11.038	11.137	0.099																
11.137	11.187	0.050																
11.187	11.487	0.300																
11.487	11.887	0.350	DRIFT			1.63E+02	2.8											
11.887	12.887	1.000	COL1															
12.887	12.887	0.150																
12.987	13.237	0.250																
13.237	13.287	0.050																
13.287	13.487	0.200																
13.487	13.537	0.050																
13.537	13.837	0.300																
13.837	14.187	0.350																
14.187	15.187	1.000	DRIFT			4.26E+02	1.7											
15.187	16.087	0.900	QUAD						7.15E+01	2.8	2.83E+00	10.5	1.76E+01	15.5		1.56E+00	36.5	
16.087	16.757	0.670	DRIFT			1.45E+03	1.2											
16.757	17.426	0.670				1.62E+03	1.1											
17.426	18.096	0.670				1.78E+03	1.0											
18.096	19.096	1.000	DRIFT			1.83E+03	0.8											
19.096	19.246	0.150	COL2															
19.246	19.496	0.250																
19.496	19.546	0.050																
19.546	19.746	0.200																
19.746	19.796	0.050																
19.796	20.096	0.300																
20.096	20.446	0.350																
20.446	21.446	1.000	DRIFT			2.34E+02	2.4											
21.446	22.346	0.900	QUAD19						1.90E+01	4.4	1.76E+00	13.1	3.34E+00	29.1		1.12E+00	44.1	
22.346	23.046	0.700	DRIFT			3.08E+02	2.5											
23.046	23.746	0.700				4.02E+02	2.1											
23.746	23.896	0.150	COL3															
23.896	24.146	0.250																
24.146	24.196	0.050																
24.196	24.396	0.200																
24.396	24.446	0.050																
24.446	24.746	0.300																
24.746	25.096	0.350	DRIFT			1.13E+02	4.6											
25.096	25.625	0.525				1.13E+02	4.4											
25.625	26.155	0.530																
26.155	26.365	0.150	COL4															
26.365	26.555	0.200																
26.555	26.605	0.050																
26.605	26.855	0.200																
26.855	26.855	0.050																
26.855	27.155	0.300																
27.155	27.505	0.350	DRIFT			6.60E+01	5.1											
27.505	28.205	0.700				7.66E+01	4.9											
28.205	28.905	0.700							1.87E+01	6.1	4.81E-01	26.4	3.75E+00	40.3		3.19E-01	49.5	
28.905	29.605	0.700	QUAD			5.43E+01	5.6											
29.605	30.305	0.700	DRIFT			5.47E+01	5.7											
30.305	31.005	0.700																
31.005	31.155	0.150	COL5															
31.155	31.405	0.250																
31.405	31.455	0.050																
31.455	31.655	0.200																
31.655	31.705	0.050																
31.705	32.005	0.300																
32.005	32.355	0.350	DRIFT			4.39E+01	5.7											
32.355	33.200	0.845				4.71E+01	5.6											
33.200	34.046	0.845				4.33E+01	5.9											
34.046	34.891	0.845				3.70E+01	6.3											
34.891	35.736	0.845							7.11E+00	14.8	1.70E-01	43.8	1.79E+00	70.9		1.12E-01	64.0	
35.736	36.086	0.350	QUAD			3.01E+00	20.9		6.99E-02	47.0	3.01E-01	96.0				9.17E-04	46.1	
36.086	36.436	0.350	RIGHT			7.20E+00	9.7			3.75E+00	10.7	3.03E-02	26.6	5.63E-01	22.6		3.48E-01	49.1
36.436	38.236	1.800				8.51E-01	26.3			4.88E-01	40.4	6.82E-02	70.9	2.00E-01	96.6		4.98E-04	66.6
38.236	41.236	3.000	BM			6.19E-01	45.6			5.								

Table. 14 continued (2/2)

INJECTION Residual dose			Residual-dose-rate(mSv/h) Error(%)							
Location-range*	Length (m)	Module	Material Cu-Coilim	Iron1(inner)	Iron2	Iron3(outer)	Concl(inner)	Conc2	Conc3	Conc4(outer)
-8.349	-7.999	0.350	QUAD							
-7.999	-7.759	0.240	DRIFT							
-7.759	-7.059	0.700	DRIFT							
-7.059	-6.659	0.400	BUMP							
-6.659	-6.259	0.400	BUMP [*]							
-6.259	-5.459	0.800	SEPTUMINJ							
-5.459	-4.659	0.800	BUMP							
-4.659	-3.809	0.850	DRIFT							
-3.809	-2.959	0.850								
-2.959	-2.109	0.850								
-2.109	-1.259	0.850								
-1.259	-1.040	0.240	DRIFT							
-1.040	-0.540	0.500	QUAD							
-0.540	0.000	0.540	DRIFT							
0.000	0.519	0.519	DRIFT							
0.519	1.019	0.500	QUAD19							
1.019	1.259	0.240	DRIFT19							
1.259	2.059	0.800	DRIFT							
2.059	2.859	0.800	BUMP							
2.859	3.659	0.800	DRIFT							
3.659	4.459	0.800	BUMP							
4.459	4.809	0.350	DRIFT							
4.809	5.028	0.219	DRIFT							
5.028	5.928	0.900	QUAD19							
5.928	6.840	0.912	DRIFT							
6.840	7.752	0.912								
7.752	8.663	0.912								
8.663	9.575	0.912								
9.575	10.487	0.912								
10.487	10.637	0.150	TAR1							
10.637	10.887	0.250								
10.887	10.937	0.050								
10.937	11.037	0.100								
11.037	11.038	0.001								
11.038	11.137	0.099								
11.137	11.187	0.050								
11.187	11.487	0.300								
11.487	11.837	0.350								
11.837	12.837	1.000	DRIFT							
12.837	12.987	0.150	COL1							
12.987	13.237	0.250								
13.237	13.287	0.050								
13.287	13.487	0.200								
13.487	13.537	0.050								
13.537	13.837	0.300								
13.837	14.187	0.350								
14.187	15.187	1.000	DRIFT							
15.187	16.087	0.900	QUAD							
16.087	16.777	0.670	DRIFT							
16.757	16.926	0.800								
17.426	18.096	0.670								
18.096	19.096	1.000	DRIFT							
19.096	19.246	0.150	COL2							
19.246	19.496	0.250								
19.496	19.546	0.050								
19.546	19.746	0.200								
19.746	19.796	0.050								
19.796	20.096	0.300								
20.096	20.446	0.350								
20.446	21.446	1.000	DRIFT							
21.446	22.346	0.900	QUAD19							
22.346	23.046	0.700	DRIFT							
23.046	23.746	0.700								
23.746	23.896	0.150	COL3							
23.896	24.146	0.250								
24.146	24.196	0.050								
24.196	24.396	0.200								
24.396	24.446	0.050								
24.446	24.746	0.300								
24.746	25.096	0.350	DRIFT							
25.096	25.625	0.529								
25.625	26.155	0.530								
26.155	26.305	0.150	COL4							
26.305	26.555	0.250								
26.555	26.605	0.050								
26.605	26.805	0.200								
26.805	26.855	0.050								
26.855	27.155	0.300								
27.155	27.505	0.350	DRIFT							
27.505	28.205	0.700								
28.205	28.905	0.700	QUAD							
28.905	29.605	0.700	DRIFT							
29.605	30.305	0.700								
30.305	31.005	0.700								
31.005	31.155	0.150	COL5							
31.155	31.405	0.250								
31.405	31.455	0.050								
31.455	31.605	0.200								
31.605	31.705	0.050								
31.705	32.005	0.300								
32.005	32.355	0.350	DRIFT							
32.355	33.200	0.845								
33.200	34.046	0.845								
34.046	34.891	0.845								
34.891	35.736	0.845								
35.736	36.086	0.350	QUAD							
36.086	36.436	0.350	QUAD							
36.436	38.236	1.800	RIGHT							
38.236	41.236	3.000	BM							
41.236	42.836	1.600	LEFT							
42.836	43.536	0.700	QUAD							
43.536	44.636	1.100	RIGHT							
44.636	47.636	3.000	BM							
47.636	49.236	1.600	LEFT							
49.236	49.936	0.700	QUAD							
49.936	50.426	0.490	DRIFT							
50.426	50.826	0.400	DRIFT							
50.826	51.626	0.800	DRIFT							
51.626	52.425	0.800								
52.425	53.225	0.800								
53.225	53.725	0.500	QUAD							
53.725	54.165	0.440	DRIFT							
54.165	54.565	0.400	DRIFT							
54.565	54.985	0.420	DRIFT							
54.985	55.485	0.500	QUAD							
55.485	55.974	0.489	DRIFT							
55.974	56.374	0.400	DRIFT							
56.374	57.174	0.800	DRIFT							
57.174	57.974	0.800								
57.974	58.774	0.800								
58.774	59.474	0.700	QUAD							
59.474	60.574	1.100	RIGHT							
60.574	63.574	3.000	BM							
63.574	65.574	1.500	LEFT							
65.574	66.374	0.700	QUAD							
66.374	66.974	1.100	RIGHT							
66.974	69.974	3.000	BM							
69.974	71.574	1.600	LEFT							
71.574	71.924	0.350	QUAD							

* circumference is 348.333m

Table 15: Residual dose rates at the materials of beam line modules in the region from the kicker through extraction.

EXTRACTION Residual dose				Residual-dose-rate(mSv/h) Error(%)							
Location-range*	Length (m)	Module	Material	SUS	Iron	Ceramic	Coil	Yoke1(inner)	Yoke2	Yoke3	Yoke4(outer)
109.227	110.102	0.875	DRIFT	1.12E-03	26.9						
110.102	110.112	0.010	KICKER-e	8.26E-04	15.0						
110.112	110.252	0.140	KICKERd	7.51E-04	20.3						
110.252	110.952	0.700	KICKERS					1.04E-03	51.3	1.37E-04	28.0
110.952	111.102	0.150	KICKERd	9.05E-04	15.9			1.67E-03	32.2	4.05E-03	1.3
111.102	111.802	0.700	KICKERS					4.90E-03	28.5	3.23E-04	17.5
111.802	111.952	0.150	KICKERd	8.16E-03	3.1			4.58E-03	30.7	4.59E-03	1.7
111.952	112.602	0.650	KICKERS					7.71E-03	30.5	4.83E-03	2.4
112.602	112.752	0.150	KICKERd	1.50E-02	55.1					3.33E-03	83.6
112.752	113.402	0.650	KICKERS								
113.402	113.552	0.150	KICKERd	3.41E-03	11.1						
113.552	114.202	0.650	KICKERS								
114.202	114.342	0.140	KICKERd	2.43E-03	12.1						
114.342	114.352	0.010	KICKER-e	2.52E-02	2.0						
114.352	114.852	0.500	DRIFT	3.77E-02	1.0						
114.852	115.071	0.219	DRIFT	3.86E-03	32.3						
115.071	115.571	0.500	QUAD					1.47E-02	19.1	4.66E-03	50.0
115.571	116.111	0.540	DRIFT	2.88E-03	12.3			2.69E-04	33.6		6.41E-04
116.111	116.630	0.519	DRIFT	5.10E-03	21.6						18.9
116.630	117.130	0.500	QUAD					3.82E-02	27.6	6.22E-03	33.3
117.130	117.370	0.240	DRIFT	5.08E-03	14.8			6.92E-04	30.6		7.32E-03
117.370	117.870	0.500	DRIFT	3.65E-03	12.9						2.9
117.870	117.880	0.010	KICKER-e	2.10E-02	1.6						
117.880	118.020	0.140	KICKERd	1.23E-02	3.4						
118.020	118.720	0.700	KICKERS								
118.720	118.870	0.150	KICKERd	2.60E-02	1.8						
118.870	119.570	0.700	KICKERS								
119.570	119.720	0.150	KICKERd	2.25E-02	36.8						
119.720	120.370	0.650	KICKERS								
120.370	120.510	0.140	KICKERd	3.33E-02	40.0						
120.510	120.520	0.010	KICKER-e	3.56E-02	41.6						
120.520	120.920	0.400	DRIFT	4.47E-01	39.1						
120.920	121.139	0.219	DRIFT	1.82E-01	58.7						
121.139	122.399	0.600	QUAD								
122.039	122.279	0.240	DRIFT	3.85E-01	50.6						
122.279	123.029	0.750	DRIFT	7.43E-01	18.8						
123.029	123.779	0.750		1.86E+00	12.6						
123.779	124.529	0.750		5.85E+00	7.0						
124.529	125.279	0.750		1.09E+02	1.5						
125.279	126.179	0.900	SEPTUMA	7.81E+02	0.5	4.14E+03	0.5				
126.179	126.679	0.500	DRIFT	2.86E+02	1.0						
126.679	127.579	0.900	SEPTUMB	9.69E+01	1.4	1.05E+02	3.4				
127.579	128.279	0.700	DRIFT	3.79E+01	2.4						
128.279	129.179	0.900	SEPTUMC	2.81E+01	2.8	9.24E+00	9.9				
129.179	129.679	0.500	DRIFT	1.73E+01	4.4						
129.679	130.579	0.900	SEPTUD	1.97E+01	3.4	2.74E+00	7.5				
130.579	131.079	0.500	DRIFT	1.21E+01	5.3						
131.079	131.298	0.219	DRIFT	1.38E+01	7.2						
131.298	132.198	0.900	QUAD								
132.198	133.091	0.893	DRIFT	1.09E+01	4.6						
133.091	133.984	0.893		9.90E+00	4.7						
133.984	134.878	0.893		6.77E+00	5.4						
134.878	135.771	0.893		6.34E+00	5.8						
135.771	136.664	0.893		7.16E+00	5.6						
136.664	137.557	0.893		6.22E+00	5.8						
137.557	138.457	0.900	QUAD								
138.457	139.394	0.937	DRIFT	4.79E+00	6.6						
139.394	140.331	0.937		2.43E+00	8.7						
140.331	141.268	0.937		3.00E+00	8.6						
141.268	142.208	0.937		1.95E+00	10.2						
142.208	143.142	0.937		1.75E+00	11.0						
143.142	144.079	0.937		1.64E+00	11.5						
144.079	145.016	0.937		1.42E+00	12.5						
145.016	145.716	0.700	QUAD								
145.716	146.592	0.876	DRIFT	2.72E-01	23.9						
146.592	147.468	0.876		1.67E-01	40.0						
147.468	148.344	0.876		1.77E-01	28.3						
148.344	149.219	0.876		1.87E-01	27.5						
149.219	150.065	0.876		4.15E-02	45.5						
150.065	150.771	0.876		6.75E-04	49.6						
150.771	151.847	0.876		8.34E-02	50.6						
151.847	152.197	0.350	QUAD								
152.197	152.547	0.350	QUAD	2.40E-02	47.2	1.37E-02	49.5	1.23E-02	94.7		
152.547	154.347	1.800	RIGHT	1.03E-02	62.9	2.71E-02	48.7	2.01E-03	79.9	7.14E-02	96.5
154.347	157.347	3.000	BM			2.23E-02	14.1	5.33E-03	31.8	7.39E-03	65.4
157.347	158.947	1.600	LEFT	7.97E-02	40.0					1.60E-02	61.6
158.947	159.647	0.700	QUAD			3.13E-02	65.7	5.38E-03	69.4	6.03E-03	95.7
159.647	160.747	1.100	RIGHT	1.09E-04	64.2					5.35E-02	48.0
160.747	163.747	3.000	BM			2.61E-02	43.1	5.60E-04	55.3	4.42E-03	70.6
163.747	165.347	1.600	LEFT	1.15E-02	1.3					1.79E-03	93.5
165.347	166.047	0.700	QUAD			7.49E-03	100.0	1.90E-03	78.0	1.60E-02	1.2
166.047	166.537	0.490	DRIFT	4.96E-05	84.0						
166.537	166.937	0.400	DRIFT	2.52E-04	64.2						
166.937	167.737	0.800	DRIFT	3.74E-05	84.0						
167.737	168.536	0.800		4.54E-02	64.4						
168.536	169.336	0.800		1.17E-04	51.4						
169.336	169.836	0.500	QUAD			1.75E-02	81.4	3.50E-03	68.7	8.32E-03	96.6

* circumference is 348.333m

Table 16: Residual dose rates at the local shields in the collimator region, the injection septum region, and the extraction septum region

COLLIMATOR Residual dose								
Location-range (m)		Length (m)	Residual-dose-rate(mSv/h)				Error(%)	
			Detector		ironL	ConL2		
ConL1	ironL	ConL2						
11.944	12.644	0.700	1.84E-01	5.1	1.14E-01	17.8	1.64E-02	8.8
14.248	14.948	0.700	6.53E-01	3.0	9.10E-01	5.6	7.35E-02	4.4
16.894	17.594	0.700	1.40E+00	2.0	1.60E+00	4.4	1.05E-01	3.8
17.594	18.294	0.700	1.72E+00	1.9	1.86E+00	3.9	7.60E-02	4.4
18.294	18.894	0.600	1.93E+00	1.8	2.10E+00	3.9	1.11E-01	4.0
20.497	21.197	0.700	5.74E-01	3.2	8.47E-01	5.9	7.87E-02	4.4
23.028	23.728	0.700	4.03E-01	3.8	3.63E-01	9.3	3.52E-02	6.6
25.308	26.008	0.700	3.32E-01	4.4	4.51E-01	8.1	3.76E-02	6.6
27.556	28.056	0.500	1.10E-01	8.8	1.45E-01	16.6	1.86E-02	11.0
29.978	30.678	0.700	6.80E-02	9.4	6.79E-02	22.2	8.23E-03	11.9
33.155	33.955	0.800	1.14E-01	5.8			2.41E-02	8.1

INJECTION Residual dose								
Location-range (m)		Length (m)	Residual-dose-rate(mSv/h)				Error(%)	
			Detector		ironL	ConL2		
ConL1	ironL	ConL2						
-7.559	-6.526	1.033	1.43E-01	2.9	3.15E-02	19.6	7.53E-04	26.5
-6.526	-5.492	1.033	4.52E-01	1.6	2.70E-01	5.8	4.52E-03	14.3
-5.492	-4.459	1.033	5.21E-01	1.5	5.77E-01	3.7	1.15E-02	9.2
-4.459	-3.659	0.800	1.62E+00	0.9	2.15E+00	1.5	4.37E-02	3.7

EXTRACTION Residual dose										
Location-range (m)		Length (m)	Residual-dose-rate(mSv/h)				Error(%)			
			Detector		ironL	ConL2				
ConL1	ironL	ConL2	ironT							
124.779	126.354	1.575	1.49E+00	0.2	1.27E+00	0.6	1.93E-02	1.7	1.27E-01	3.1
126.354	127.929	1.575	9.05E-01	0.3	1.30E+00	0.7	2.07E-02	1.8	1.58E-01	3.0
127.929	129.504	1.575	2.58E-01	0.7	3.95E-01	1.3	5.93E-03	3.3	4.74E-02	5.3
129.504	131.079	1.575	8.26E-02	1.3	1.07E-01	2.6	1.77E-03	5.7	1.51E-02	10.0

Table 17: Absorbed dose rates inside the concrete shield wall of tunnel in the region from the injection through collimator.

INJECTION Absorbed dose		Length (m)	Absorbed-dose-rate(Gy/sec) Error(%)							
Location-range (m)	Detector*		UC1	UCs	DC1	DCs	IC1	OC1		
-8.349	-7.349	1.000	2.43E-06	48.5	7.54E-07	56.5	2.13E-04	14.5	3.61E-07	100.0
-7.349	-6.299	1.050	6.44E-06	67.3	8.28E-07	52.8	6.73E-04	5.7	1.22E-06	69.4
-6.299	-5.249	1.050	6.34E-06	47.2	6.44E-07	56.3	1.91E-03	4.0	5.97E-08	100.0
-5.249	-4.199	1.050	2.16E-05	77.9	3.58E-07	88.2	2.04E-03	6.2	2.21E-07	61.3
-4.199	-3.150	1.050	1.01E-05	37.5	1.24E-06	61.3	1.89E-04	27.1	9.90E-07	56.2
-3.150	-2.100	1.050	9.66E-06	33.6	9.40E-06	84.7	1.36E-04	28.5	2.15E-06	75.2
-2.100	-1.050	1.050	2.71E-05	62.2	3.96E-06	41.9	1.57E-04	33.6	8.83E-07	48.4
-1.050	0.000	1.050	5.31E-05	47.4	7.23E-06	35.2	1.54E-04	28.2	3.56E-06	39.8
0.000	1.000	1.000	3.72E-05	55.1	1.32E-05	67.9	4.84E-05	46.2	7.73E-07	48.4
1.000	2.000	1.000	7.99E-06	41.8	3.51E-06	60.1	3.81E-05	38.2	1.44E-06	69.6
2.000	3.000	1.000	2.84E-05	58.4	9.22E-06	67.4	5.11E-05	41.7	1.69E-05	90.5
3.000	4.000	1.000	1.75E-05	42.3	8.45E-07	53.6	2.67E-05	63.9	1.45E-06	64.2
4.000	5.000	1.000	3.95E-06	35.0	2.01E-05	88.1	6.96E-05	67.1	3.79E-06	58.2
5.000	6.000	1.000	2.69E-05	67.0	5.18E-05	74.2	4.36E-06	45.6	2.71E-05	69.1
6.000	7.000	1.000	5.48E-05	66.7	2.69E-05	73.3	2.51E-05	81.7	5.90E-06	65.7
7.000	8.000	1.000	2.32E-06	72.7	2.34E-06	51.6	4.17E-05	58.4	2.66E-05	75.5
8.000	9.000	1.000	2.48E-06	36.2	1.10E-05	84.9	2.62E-05	88.7	4.36E-06	48.4
9.000	10.000	1.000	1.37E-05	52.1	5.19E-06	35.0	4.12E-05	75.8	6.16E-05	82.1
10.000	11.000	1.000	3.22E-06	33.6	9.91E-06	33.8	3.29E-06	30.5	9.31E-06	45.3
11.000	12.000	1.000	2.52E-05	32.0	2.31E-05	51.5	1.22E-04	20.5	1.68E-05	27.1
12.000	13.000	1.000	5.07E-05	37.0	3.26E-05	29.5	2.99E-04	16.2	4.61E-05	32.4
13.000	14.000	1.000	5.14E-05	20.9	9.82E-05	59.0	1.18E-03	6.9	4.05E-05	16.1
14.000	15.000	1.000	9.08E-05	22.2	5.33E-05	51.0	6.11E-04	10.8	4.90E-05	20.1
15.000	15.833	0.833	1.38E-04	25.5	7.08E-05	37.4	1.21E-03	11.0	3.94E-05	42.7
15.833	16.667	0.833	1.83E-04	19.5	6.98E-05	33.6	1.41E-03	8.5	3.38E-05	27.5
16.667	17.500	0.833	2.39E-04	24.4	3.50E-05	26.2	3.74E-03	6.2	6.30E-05	35.5
17.500	18.487	0.987	1.19E-04	34.6	5.90E-05	33.2	7.03E-03	5.0	2.94E-05	24.2
18.487	19.475	0.987	1.15E-04	24.5	6.96E-05	27.9	9.54E-03	4.6	5.66E-05	29.4
19.475	20.462	0.987	5.57E-05	29.1	5.70E-05	29.0	5.91E-03	6.5	5.79E-05	24.0
20.462	21.450	0.987	4.63E-05	20.5	7.98E-05	35.1	1.72E-03	11.3	5.38E-05	39.0
21.450	22.437	0.987	4.52E-05	22.5	7.41E-05	34.6	1.04E-03	12.8	5.62E-05	47.9
22.437	23.425	0.987	6.18E-05	28.0	4.49E-05	43.9	6.23E-04	12.9	8.50E-05	38.2
23.425	24.412	0.987	4.84E-05	33.0	4.30E-05	33.1	8.76E-04	11.7	6.02E-05	31.7
24.412	25.399	0.987	2.20E-05	40.1	2.45E-05	38.2	5.97E-04	15.3	1.38E-05	24.9
25.399	26.387	0.987	1.25E-05	23.0	2.26E-05	31.4	3.90E-04	16.1	3.37E-05	49.7
26.387	27.374	0.987	5.52E-05	57.4	1.21E-05	37.3	4.55E-04	16.5	1.49E-05	39.6
27.374	28.362	0.987	1.10E-05	57.8	2.63E-05	46.1	1.49E-04	17.4	3.14E-05	60.8
28.362	29.349	0.987	2.04E-05	56.2	2.01E-05	35.8	1.96E-04	31.0	1.12E-05	48.6
29.349	30.337	0.987	2.42E-05	39.6	2.12E-05	59.8	2.49E-04	27.5	5.95E-06	34.4
30.337	31.324	0.987	5.26E-06	43.5	4.31E-06	48.4	1.72E-04	26.4	1.34E-05	48.4
31.324	32.311	0.987	2.15E-05	72.1	1.55E-05	60.8	1.68E-04	29.9	1.10E-05	42.4
32.311	33.299	0.987	6.48E-06	50.1	2.11E-05	87.4	9.09E-05	35.5	2.00E-05	69.5
33.299	34.286	0.987	2.00E-05	58.1	7.40E-06	54.5	7.42E-05	46.0	2.68E-06	51.5
34.286	35.274	0.987	3.65E-05	78.2	1.65E-05	81.2	1.07E-04	43.1	4.17E-06	80.9
35.274	36.261	0.987	3.73E-06	37.2	2.43E-05	77.5	7.31E-05	35.7	2.61E-06	41.8
36.261	37.249	0.987	7.06E-06	48.8	4.79E-06	65.9	5.90E-05	55.8	2.91E-06	61.5
37.249	38.236	0.987	1.89E-05	91.9	4.67E-06	57.2	3.20E-05	55.9	2.70E-06	74.6
38.236	39.736	1.500	2.86E-06	45.5	7.68E-06	60.6	3.41E-05	62.8	2.66E-06	52.9
39.736	41.236	1.500	2.54E-05	92.1	4.92E-06	88.8	1.22E-05	97.1	1.53E-05	93.7
41.236	42.369	1.133	1.00E-05	67.8	1.25E-06	69.9	4.54E-07	81.2	3.79E-05	88.8
42.369	43.503	1.133	2.72E-05	83.3	1.47E-06	49.6	1.38E-05	77.9	5.69E-08	100.0
43.503	44.636	1.133	8.83E-06	82.0	1.90E-05	99.0	1.79E-07	100.0	7.53E-07	74.0
44.636	46.136	1.500	3.81E-06	80.1	0.00E+00	0.0	1.68E-05	97.0	1.02E-07	100.0
46.136	47.636	1.500	5.42E-08	100.0	7.42E-07	90.7	3.75E-07	100.0	3.52E-07	100.0
47.636	48.818	1.182	1.55E-07	80.9	8.13E-07	100.0	0.00E+00	0.0	8.43E-07	100.0
48.818	50.000	1.182	0.00E+00	0.0	0.00E+00	0.0	7.07E-07	95.8	2.15E-07	82.8
50.000	51.175	1.175	4.69E-07	100.0	1.80E-07	100.0	1.03E-06	75.3	0.00E+00	0.0
51.175	52.350	1.175	1.64E-06	93.5	0.00E+00	0.0	4.95E-06	96.8	2.71E-06	100.0
52.350	53.525	1.175	2.02E-07	71.3	0.00E+00	0.0	4.85E-07	74.6	0.00E+00	0.0
53.525	54.700	1.175	7.37E-07	69.1	4.31E-06	100.0	1.00E-07	80.7	0.00E+00	0.0
54.700	55.874	1.175	8.12E-07	100.0	3.52E-07	100.0	0.00E+00	0.0	1.09E-07	100.0
55.874	57.049	1.175	6.83E-07	99.5	2.20E-07	100.0	2.06E-05	99.8	1.28E-07	100.0
57.049	58.224	1.175	2.05E-07	58.6	3.82E-06	72.2	0.00E+00	0.0	3.81E-08	100.0
58.224	59.399	1.175	2.58E-06	67.4	6.76E-06	61.4	2.24E-05	85.9	0.00E+00	0.0
59.399	60.574	1.175	1.46E-06	66.8	1.01E-07	100.0	3.75E-06	32.9	1.31E-07	100.0
60.574	62.074	1.500	5.52E-07	100.0	5.90E-07	100.0	1.56E-07	81.0	5.30E-07	72.6
62.074	63.574	1.500	9.87E-07	70.8	4.09E-07	100.0	2.04E-06	72.0	9.84E-07	100.0
63.574	64.707	1.133	0.00E+00	0.0	0.00E+00	0.0	0.00E+00	0.0	0.00E+00	0.0
64.707	65.841	1.133	1.02E-07	100.0	0.00E+00	0.0	1.43E-07	100.0	0.00E+00	0.0
65.841	66.974	1.133	0.00E+00	0.0	0.00E+00	0.0	4.94E-08	100.0	0.00E+00	0.0
66.974	68.474	1.500	0.00E+00	0.0	0.00E+00	0.0	1.58E-07	100.0	7.38E-07	100.0
68.474	69.974	1.500	0.00E+00	0.0	0.00E+00	0.0	0.00E+00	0.0	0.00E+00	0.0
69.974	71.341	1.367	0.00E+00	0.0	0.00E+00	0.0	3.62E-07	100.0	2.19E-05	100.0

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table 18: Absorbed dose rates inside the concrete shield wall of tunnel in the region from the kicker through extraction.

EXTRACTION Absorbed dose		Length (m)	Detector*	Absorbed-dose-rate(Gy/sec) Error(%)										
Location-range (m)	Length (m)			UC1	UCs	DC1	DCs	IC1	OC1					
109.648	110.927	1.279	1.07E-05	36.9	1.00E-05	22.4	1.22E-06	22.4	9.15E-06	28.3	1.78E-05	25.4	8.85E-06	27.3
110.927	112.206	1.279	1.05E-05	25.2	1.29E-05	20.7	1.23E-06	20.0	7.41E-06	28.3	1.95E-05	14.8	1.30E-05	29.4
112.206	113.485	1.279	1.78E-05	20.5	2.71E-05	22.7	2.35E-06	19.9	1.15E-05	24.8	2.53E-05	15.8	2.06E-05	20.9
113.485	114.764	1.279	1.52E-05	16.2	2.92E-05	15.6	3.20E-06	22.3	1.83E-05	21.1	3.75E-05	15.1	2.51E-05	15.8
114.764	116.042	1.279	2.93E-05	17.4	4.07E-05	14.8	3.07E-06	16.1	1.93E-05	26.3	4.18E-05	13.6	4.34E-05	13.9
116.042	117.321	1.279	4.19E-05	11.5	5.34E-05	14.2	5.37E-06	22.3	2.08E-05	17.7	6.22E-05	9.6	6.03E-05	11.5
117.321	118.600	1.279	6.16E-05	11.0	5.76E-05	10.9	1.69E-05	18.9	3.77E-05	15.9	6.11E-05	9.8	1.07E-04	8.5
118.600	119.600	1.000	7.79E-05	8.9	7.21E-05	14.1	3.28E-05	15.3	5.04E-05	14.8	5.23E-05	12.2	1.31E-04	7.8
119.600	120.600	1.000	1.15E-04	8.8	7.33E-05	11.4	7.79E-05	11.6	4.68E-05	16.6	4.58E-05	11.8	2.65E-04	5.7
120.600	121.631	1.031	1.59E-04	6.3	3.67E-05	12.5	1.66E-04	7.5	3.68E-05	16.6	3.96E-05	11.9	1.74E-04	6.8
121.631	122.662	1.031	2.38E-04	5.6	2.70E-05	16.0	3.01E-04	5.1	2.37E-05	16.8	2.42E-05	11.9	1.94E-04	7.0
122.662	123.692	1.031	2.03E-04	6.1	1.35E-05	15.0	7.79E-04	3.5	1.43E-05	17.5	2.21E-05	11.4	1.10E-04	8.8
123.692	124.723	1.031	4.21E-05	10.2	1.14E-05	20.0	2.21E-03	2.1	8.68E-06	17.3	1.45E-05	13.9	1.72E-05	10.9
124.723	125.754	1.031	1.68E-05	16.4	7.03E-06	13.0	4.86E-03	1.5	1.39E-05	28.3	1.49E-05	21.6	8.89E-06	22.4
125.754	126.785	1.031	1.90E-05	19.0	6.80E-06	25.2	8.65E-03	1.4	1.33E-05	21.6	1.83E-05	23.1	6.17E-06	18.7
126.785	127.815	1.031	2.45E-05	22.1	7.56E-06	32.7	7.56E-03	1.7	1.18E-05	24.8	2.26E-05	28.5	3.14E-06	25.5
127.815	128.846	1.031	1.38E-05	29.8	7.15E-06	29.4	5.40E-03	2.5	1.34E-05	24.4	1.93E-05	21.8	3.46E-06	27.2
128.846	129.877	1.031	7.34E-06	25.0	9.49E-06	51.0	3.27E-03	3.5	6.17E-06	60.0	1.20E-05	22.2	7.00E-06	31.2
129.877	130.908	1.031	1.02E-05	25.3	7.20E-06	33.0	2.09E-03	4.6	9.06E-06	38.7	1.43E-05	29.3	5.96E-06	27.2
130.908	131.938	1.031	1.71E-05	20.0	6.95E-06	30.6	1.25E-03	5.9	4.79E-06	24.6	1.25E-05	19.8	4.56E-06	26.7
131.938	132.969	1.031	3.25E-05	18.0	1.61E-05	29.2	8.40E-04	8.0	5.01E-06	27.4	1.96E-05	24.0	1.20E-05	33.6
132.969	134.000	1.031	3.96E-05	15.9	1.25E-05	25.9	6.01E-04	8.4	1.34E-05	31.7	1.73E-05	23.6	1.15E-05	23.3
134.000	135.000	1.000	4.96E-05	18.9	1.51E-05	23.3	5.71E-04	10.2	1.28E-05	35.1	1.47E-05	26.6	1.48E-05	28.4
135.000	136.000	1.000	5.77E-05	21.7	2.35E-05	33.7	3.44E-04	10.9	2.02E-05	43.6	1.80E-05	33.9	1.10E-05	33.2
136.000	137.000	1.000	6.12E-05	15.4	1.49E-05	26.9	1.60E-04	18.6	1.49E-05	40.9	1.97E-05	23.7	1.58E-05	31.4
137.000	138.000	1.000	5.57E-05	20.9	6.71E-06	24.7	2.75E-05	20.2	2.59E-05	31.5	1.03E-05	25.9	1.89E-05	23.7
138.000	139.000	1.000	3.95E-05	26.9	2.15E-05	31.0	2.48E-05	22.5	2.26E-05	36.0	2.65E-05	22.2	1.35E-05	28.8
139.000	140.000	1.000	4.19E-05	30.1	1.79E-05	32.0	3.23E-05	22.9	9.23E-06	37.2	1.56E-05	32.2	8.37E-06	43.9
140.000	141.000	1.000	1.91E-05	28.7	1.08E-05	35.4	4.25E-05	23.5	4.34E-06	36.6	1.10E-05	33.2	9.14E-06	41.1
141.000	142.000	1.000	3.07E-05	25.4	1.20E-05	47.3	4.74E-05	22.6	1.36E-05	48.2	2.95E-05	26.5	9.60E-06	42.4
142.000	143.235	1.235	1.39E-05	30.4	1.55E-05	38.0	6.33E-05	21.9	9.59E-06	57.8	2.43E-05	23.1	7.30E-06	30.0
143.235	144.469	1.235	8.89E-06	29.9	1.14E-05	35.3	4.01E-05	28.1	8.46E-06	43.6	1.66E-05	30.8	1.20E-05	54.9
144.469	145.704	1.235	1.64E-05	33.6	5.78E-06	40.9	3.13E-05	30.3	1.39E-05	39.3	1.17E-05	33.0	3.26E-06	65.5
145.704	146.939	1.235	7.03E-06	44.7	3.26E-06	37.0	1.91E-05	35.7	8.12E-06	74.5	9.45E-06	38.7	1.15E-05	32.7
146.939	148.174	1.235	1.83E-05	41.9	6.28E-06	53.6	1.24E-05	47.5	4.71E-06	48.7	1.12E-05	40.5	2.26E-06	41.3
148.174	149.408	1.235	9.53E-06	42.9	5.92E-06	50.0	2.33E-06	66.8	4.92E-06	52.1	7.55E-06	62.4	2.92E-06	63.3
149.408	150.643	1.235	2.63E-06	70.2	5.10E-06	51.9	6.72E-06	93.7	8.61E-06	76.0	1.31E-05	43.1	5.93E-06	65.1
150.643	151.878	1.235	1.51E-05	56.8	1.04E-05	54.7	6.48E-07	69.7	2.73E-07	44.1	6.90E-06	45.6	1.56E-07	56.7
151.878	153.112	1.235	5.05E-06	51.1	4.35E-06	50.6	1.98E-06	90.1	7.36E-06	87.1	1.03E-05	56.1	3.38E-06	95.4
153.112	154.347	1.235	9.45E-07	83.9	4.64E-06	94.3	1.30E-06	91.6	1.61E-07	62.6	6.04E-06	54.7	6.09E-06	54.3
154.347	155.847	1.500	1.30E-07	47.9	2.17E-06	98.4	3.94E-06	70.9	2.17E-07	40.0	2.41E-06	63.7	2.05E-06	50.5
155.847	157.347	1.500	1.13E-06	72.8	6.12E-06	89.6	7.98E-07	90.0	1.14E-05	60.5	4.55E-06	66.1	6.80E-06	88.9
157.347	159.047	1.700	6.19E-07	83.6	3.40E-06	52.2	7.76E-07	91.8	6.75E-06	65.8	9.58E-07	62.8	7.28E-07	88.2
159.047	160.747	1.700	2.63E-07	60.9	7.36E-07	82.8	1.41E-06	82.6	4.21E-06	73.3	1.27E-06	97.8	5.51E-06	80.8
160.747	162.247	1.500	4.36E-09	100.0	1.71E-07	83.8	7.55E-08	59.8	1.89E-07	100.0	1.87E-06	95.7	2.53E-06	93.0
162.247	163.747	1.500	0.00E+00	0.0	4.47E-06	98.4	1.63E-07	100.0	1.41E-06	100.0	2.22E-06	76.9	8.63E-09	60.7
163.747	165.364	1.617	1.61E-06	96.0	4.26E-07	54.8	2.24E-07	90.8	9.85E-08	59.2	2.80E-08	100.0	5.48E-08	75.9
165.364	166.981	1.617	1.27E-06	96.1	2.09E-08	75.3	0.00E+00	0.0	1.06E-06	100.0	0.00E+00	0.0	4.21E-08	71.1
166.982	168.599	1.617	4.57E-07	92.4	2.04E-07	68.8	3.87E-06	73.9	5.23E-08	73.9	4.00E-07	98.7	0.00E+00	0.0

* Detector name means

Direction - "U";upward, "D";downward, "I";inward and "O";outward.

Shield - "C":concrete and "S":soil.

Table 19: Absorbed dose rates at the materials of beam line modules in the region from the injection through collimator. (1/2)

INJECTION Absorbed dose			Absorbed-dose-rate(Gy/sec) Error(%)									
Location-range*	Length (m)	Module	Material		SUS	Iron	Ceramic	Coil	Yoke1(inner)	Yoke2	Yoke3	Yoke4(outer)
-8.349	-7.999	0.350	QUAD		1.30E-04	31.0	9.81E-05	42.0	5.46E-05	59.9		
-7.999	-7.759	0.240	DRIFT		2.02E-04	20.6						
-7.759	-7.059	0.240	DRIFT									
-7.059	-6.659	0.400	BUMP									
-6.659	-6.259	0.400	BUMP									
-6.259	-5.459	0.800	SEPTUMINJ	2.02E-01	1.9	1.86E+00	1.2					
-5.459	-4.659	0.800	BUMP									
-4.659	-3.809	0.850	DRIFT		3.74E-01	2.6						
-3.809	-2.959	0.850			7.13E-02	5.5						
-2.959	-2.109	0.850			4.17E-02	7.4						
-2.109	-1.259	0.850			3.51E-02	8.5						
-1.259	-1.040	0.219	DRIFT		2.90E-02	16.8						
-1.040	-0.540	0.500	QUAD									
-0.540	0.000	0.540	DRIFT		2.84E-02	12.4						
0.000	0.519	0.519	DRIFT		2.85E-02	12.4						
0.519	1.019	0.500	QUAD19									
1.019	1.259	0.240	DRIFT19		2.94E-03	37.7						
1.259	2.059	0.800	DRIFT		4.23E-02	8.5						
2.059	2.859	0.800	BUMP									
2.859	3.659	0.800	DRIFT		4.91E-03	21.9						
3.659	4.459	0.800	BUMP									
4.459	4.809	0.350	DRIFT		1.13E-02	23.7						
4.809	5.028	0.219	DRIFT		2.21E-02	22.3						
5.028	5.928	0.900	QUAD19									
5.928	6.840	0.912	DRIFT		3.12E-02	9.7						
6.840	7.752	0.912			2.78E-02	10.4						
7.752	8.663	0.912			3.97E-03	22.5						
8.663	9.575	0.912			2.02E-03	32.3						
9.575	10.487	0.912			2.32E-03	33.8						
10.487	10.637	0.150	TAR1									
10.637	10.887	0.250										
10.887	10.937	0.050										
10.937	11.037	0.100										
11.037	11.038	0.001										
11.038	11.137	0.099										
11.137	11.187	0.050										
11.187	11.487	0.300										
11.487	11.887	0.350	DRIFT		2.73E-01	2.9						
11.887	12.837	1.000	COL1									
12.837	12.887	0.150										
12.887	13.237	0.250										
13.237	13.287	0.050										
13.287	13.487	0.200										
13.487	13.537	0.050										
13.537	13.837	0.300										
13.837	14.187	0.350										
14.187	15.187	1.000	DRIFT		7.25E-01	1.7						
15.187	16.087	0.900	QUAD									
16.087	16.757	0.670	DRIFT		2.67E+00	1.2						
16.757	17.426	0.670			3.03E+00	1.1						
17.426	18.096	0.670			3.30E+00	1.1						
18.096	19.096	1.000	DRIFT		3.36E+00	0.9						
19.096	19.246	0.150	COL2									
19.246	19.496	0.250										
19.496	19.546	0.050										
19.546	19.746	0.200										
19.746	19.796	0.050										
19.796	20.096	0.300										
20.096	20.446	0.350										
20.446	21.446	1.000	DRIFT		3.39E-01	2.3						
21.446	22.346	0.900	QUAD19									
22.346	23.046	0.700	DRIFT		5.49E-01	2.6						
23.046	23.746	0.700	COL3		7.42E-01	2.3						
23.746	23.896	0.150										
23.896	24.146	0.250	DRIFT		1.94E-01	4.0						
24.146	24.196	0.050	COL4		2.17E-01	4.0						
24.196	24.396	0.200										
24.396	24.446	0.050										
24.446	24.746	0.300										
24.746	25.096	0.350										
25.096	25.625	0.525	DRIFT		1.15E-01	4.7						
25.625	26.155	0.530			1.45E-01	4.5						
26.155	26.305	0.150	DRIFT		1.04E-01	5.6						
26.305	26.555	0.200	COL5		9.56E-02	6.0						
26.555	26.605	0.050										
26.605	26.805	0.200										
26.805	26.855	0.050										
26.855	27.155	0.300										
27.155	27.505	0.350	DRIFT		1.55E-01	4.8						
27.505	28.205	0.700			1.82E-03	28.6						
28.205	28.905	0.700	QUAD		6.69E-03	19.9						
28.905	29.605	0.700	DRIFT		1.55E-01	4.8						
29.605	30.305	0.700	COL6		1.82E-03	28.6						
30.305	31.005	0.700			6.69E-03	16.8						
31.005	31.155	0.150	COL5									
31.155	31.405	0.250										
31.405	31.455	0.050										
31.455	31.655	0.200										
31.655	31.705	0.050										
31.705	32.005	0.300										
32.005	32.355	0.350	DRIFT		8.27E-02	4.9						
32.355	33.200	0.845			9.56E-02	5.2						
33.200	34.046	0.845	QUAD		7.92E-02	6.0						
34.046	34.891	0.845	RIGHT		7.31E-02	6.5						
34.891	35.736	0.845	BM									
35.736	36.086	0.350	DRIFT		1.48E-02	9.8						
36.086	36.436	0.350	RIGHT		3.36E-02	8.4						
36.436	38.236	1.800	BM		1.27E-03	46.0						
38.236	41.236	3.000	DRIFT		3.64E-04	68.2						
41.236	42.836	1.600	LEFT		1.21E-03	14.2						
42.836	43.536	0.700	QUAD		4.52E-04	31.1						
43.536	44.636	1.100	RIGHT		3.54E-08	95.7						
44.636	47.636	3.000	BM		2.45E-06	54.0						
47.636	49.236	1.600	LEFT		4.88E-03	40.0						
49.236	49.936	0.700	QUAD		2.05E-04	57.9						
49.936	50.426	0.450	DRIFT		4.81E-03	30.9						
50.426	50.826	0.400			2.79E-03	40.3						
50.826	51.626	0.800	DRIFT		2.05E-03	30.1						
51.626	52.426	0.800	DRIFT		1.61E-03	41.6						
52.426	53.225	0.500	QUAD		2.93E-03	31.6						
53.225	53.725	0.500	DRIFT		3.36E-03	39.3						
53.725	54.165	0.440			4.10E-05	99.9						
54.165	54.565	0.400	DRIFT		5.96E-05	84.6						
54.565	54.985	0.420	DRIFT		9.17E-04	59.5						
54.985	55.485	0.500	QUAD		1.72E-04	99.5						
55.485	55.974	0.489	DRIFT		9.95E-04	54.7						
55.974	56.374	0.400	DRIFT		6.08E-05	95.9						
56.374	57.174	0.800	DRIFT		7.75E-04	58.7						
57.174	57.974	0.800	QUAD		5.28E-04	76.2						
57.974	58.774	0.800	RIGHT		2.35E-04	61.7						
58.774	59.474	0.700	BM		5.95E-02	6.2						
59.474	60.574	1.100	RIGHT		3.95E-05	34.2						
60.574	63.574	3.000	BM		3.58							

Table. 19 continued (2/2)

INJECTION Absorbed dose									
Location-range*	Length (m)	Module	Absorbed-dose-rate(Gy/sec) Error(%)						
		Material Cu-Coilim	Iron1(inner)	Iron2	Iron3(outer)	Conc1(inner)	Conc2	Conc3	Conc4(outer)
-8.349	-7.999	0.350	QUAD						
-7.999	-7.759	0.240	DRIFT						
-7.759	-7.059	0.700	DRIFT						
-7.059	-6.659	0.400	BUMP						
-6.659	-6.259	0.400	BUMP [*]						
-6.259	-5.459	0.800	SEPTUMINJ						
-5.459	-4.659	0.800	BUMP						
-4.659	-3.809	0.850	DRIFT						
-3.809	-2.959	0.850							
-2.959	-2.109	0.850							
-2.109	-1.259	0.850							
-1.259	-1.040	0.240	DRIFT						
-1.040	-0.540	0.500	QUAD						
-0.540	0.000	0.540	DRIFT						
0.000	0.519	0.519	DRIFT						
0.519	1.019	0.500	QUAD19						
1.019	1.259	0.240	DRIFT19						
1.259	2.059	0.800	DRIFT						
2.059	2.859	0.800	BUMP						
2.859	3.659	0.800	DRIFT						
3.659	4.459	0.800	BUMP						
4.459	4.809	0.350	DRIFT						
4.809	5.028	0.219	DRIFT						
5.028	5.928	0.900	QUAD19						
5.928	6.840	0.912	DRIFT						
6.840	7.752	0.912							
7.752	8.663	0.912							
8.663	9.575	0.912							
9.575	10.487	0.912							
10.487	10.637	0.150	TAR1						
10.637	10.887	0.250							
10.887	10.937	0.050							
10.937	11.037	0.100							
11.037	11.038	0.001							
11.038	11.137	0.099							
11.137	11.187	0.050							
11.187	11.487	0.300							
11.487	11.837	0.350							
11.837	12.837	1.000	DRIFT						
12.837	12.987	0.150	COL1						
12.987	13.237	0.250							
13.237	13.287	0.050							
13.287	13.487	0.200							
13.487	13.537	0.050							
13.537	13.837	0.300							
13.837	14.187	0.350							
14.187	15.187	1.000	DRIFT						
15.187	16.087	0.900	QUAD						
16.087	16.777	0.670	DRIFT						
16.757	16.826	0.800							
17.426	18.096	0.670							
18.096	19.096	1.000	DRIFT						
19.096	19.246	0.150	COL2						
19.246	19.496	0.250							
19.496	19.546	0.050							
19.546	19.746	0.200							
19.746	19.796	0.050							
19.796	20.096	0.300							
20.096	20.446	0.350							
20.446	21.446	1.000	DRIFT						
21.446	22.346	0.900	QUAD19						
22.346	23.046	0.700	DRIFT						
23.046	23.746	0.700							
23.746	23.896	0.150	COL3						
23.896	24.146	0.250							
24.146	24.196	0.050							
24.196	24.396	0.200							
24.396	24.446	0.050							
24.446	24.746	0.300							
24.746	25.096	0.350	DRIFT						
25.096	25.625	0.529							
25.625	26.155	0.530							
26.155	26.305	0.150	COL4						
26.305	26.555	0.250							
26.555	26.605	0.050							
26.605	26.805	0.200							
26.805	26.855	0.050							
26.855	27.155	0.300							
27.155	27.505	0.350	DRIFT						
27.505	28.205	0.700							
28.205	28.905	0.700	QUAD						
28.905	29.605	0.700	DRIFT						
29.605	30.305	0.700							
30.305	31.005	0.700							
31.005	31.155	0.150	COL5						
31.155	31.405	0.250							
31.405	31.455	0.050							
31.455	31.605	0.200							
31.605	31.705	0.050							
31.705	32.005	0.300							
32.005	32.355	0.350	DRIFT						
32.355	33.200	0.845							
33.200	34.046	0.845							
34.046	34.891	0.845							
34.891	35.736	0.845							
35.736	36.086	0.350	QUAD						
36.086	36.436	0.350	QUAD						
36.436	38.236	1.800	RIGHT						
38.236	41.236	3.000	BM						
41.236	42.836	1.600	LEFT						
42.836	43.536	0.700	QUAD						
43.536	44.636	1.100	RIGHT						
44.636	47.636	3.000	BM						
47.636	49.236	1.600	LEFT						
49.236	49.936	0.700	QUAD						
49.936	50.426	0.490	DRIFT						
50.426	50.826	0.400	DRIFT						
50.826	51.626	0.800	DRIFT						
51.626	52.425	0.800							
52.425	53.225	0.800							
53.225	53.725	0.500	QUAD						
53.725	54.165	0.440	DRIFT						
54.165	54.565	0.400	DRIFT						
54.565	54.985	0.420	DRIFT						
54.985	55.485	0.500	QUAD						
55.485	55.974	0.489	DRIFT						
55.974	56.374	0.400	DRIFT						
56.374	57.174	0.800	DRIFT						
57.174	57.974	0.800							
57.974	58.774	0.800							
58.774	59.474	0.700	QUAD						
59.474	60.574	1.100	RIGHT						
60.574	63.574	3.000	BM						
63.574	65.674	1.500	LEFT						
65.674	66.974	0.700	QUAD						
66.974	66.974	1.100	RIGHT						
66.974	69.974	3.000	BM						
69.974	71.574	1.600	LEFT						
71.574	71.924	0.350	QUAD						

* circumference is 348.333m

Table 20: Absorbed dose rates at the materials of beam line modules in the region from the kicker through extraction.

EXTRACTION Absorbed dose				Absorbed-dose-rate(Gy/sec) Error(%)							
Location-range*	Length (m)	Module	Material	SUS	Iron	Ceramic	Coil	Yoke1(inner)	Yoke2	Yoke3	Yoke4(outer)
109.227	110.102	0.875	DRIFT	1.32E-08	52.4						
110.102	110.112	0.010	KICKER-e	1.77E-07	43.2						
110.112	110.252	0.140	KICKERd	2.26E-07	46.5						
110.252	110.952	0.700	KICKERS								
110.952	111.102	0.150	KICKERd	1.05E-06	46.3						
111.102	111.802	0.700	KICKERS								
111.802	111.952	0.150	KICKERd	1.72E-06	30.8						
111.952	112.602	0.650	KICKERS								
112.602	112.752	0.150	KICKERd	1.54E-06	38.4						
112.752	113.402	0.650	KICKERS								
113.402	113.552	0.150	KICKERd	3.08E-06	40.9						
113.552	114.202	0.650	KICKERS								
114.202	114.342	0.140	KICKERd	3.70E-06	51.1						
114.342	114.352	0.010	KICKER-e	3.03E-06	34.6						
114.352	114.852	0.500	DRIFT	8.50E-07	56.0						
114.852	115.071	0.219	DRIFT	9.88E-06	61.4						
115.071	115.571	0.500	QUAD								
115.571	116.111	0.540	DRIFT	3.65E-06	56.0						
116.111	116.630	0.519	DRIFT	4.41E-06	44.9						
116.630	117.130	0.500	QUAD								
117.130	117.370	0.240	DRIFT	5.10E-05	87.2						
117.370	117.870	0.500	DRIFT	6.38E-06	49.0						
117.870	117.880	0.010	KICKER-e	6.74E-06	20.7						
117.880	118.020	0.140	KICKERd	2.94E-06	21.0						
118.020	118.720	0.700	KICKERS								
118.720	118.870	0.150	KICKERd	6.21E-06	19.7						
118.870	119.570	0.700	KICKERS								
119.570	119.720	0.150	KICKERd	1.60E-05	35.1						
119.720	120.370	0.650	KICKERS								
120.370	120.510	0.140	KICKERd	1.88E-05	18.7						
120.510	120.520	0.010	KICKER-e	4.00E-05	35.5						
120.520	120.920	0.400	DRIFT	1.57E-04	47.4						
120.920	121.139	0.219	DRIFT	2.01E-04	36.0						
121.139	122.399	0.600	QUAD								
122.039	122.279	0.240	DRIFT	1.37E-04	25.0						
122.279	123.029	0.750	DRIFT	3.35E-04	13.1						
123.029	123.779	0.750		1.05E-03	9.1						
123.779	124.529	0.750		3.47E-03	4.7						
124.529	125.279	0.750		8.03E-02	1.0						
125.279	126.179	0.900	SEPTUMA	5.65E-01	0.5	6.90E+00 0.4					
126.179	126.679	0.500	DRIFT	2.71E-01	1.4						
126.679	127.579	0.900	SEPTUMB	7.77E-02	1.9	1.23E-01 2.6					
127.579	128.279	0.700	DRIFT	3.45E-02	3.5						
128.279	129.179	0.900	SEPTUMC	2.72E-02	3.9	6.73E-03 6.6					
129.179	129.679	0.500	DRIFT	1.62E-02	6.1						
129.679	130.579	0.900	SEPTUD	2.08E-02	4.8	2.00E-03 7.1					
130.579	131.079	0.500	DRIFT	1.15E-02	7.8						
131.079	131.298	0.219	DRIFT	1.44E-02	9.7						
131.298	132.198	0.900	QUAD								
132.198	133.091	0.893	DRIFT	1.26E-02	6.2						
133.091	133.984	0.893		1.12E-02	6.9						
133.984	134.878	0.893		8.13E-03	7.8						
134.878	135.771	0.893		7.48E-03	8.0						
135.771	136.664	0.893		7.44E-03	8.0						
136.664	137.557	0.893		7.78E-03	8.6						
137.557	138.457	0.900	QUAD								
138.457	139.394	0.937	DRIFT	5.10E-03	9.3						
139.394	140.331	0.937		2.82E-03	12.1						
140.331	141.268	0.937		3.62E-03	12.5						
141.268	142.208	0.937		2.09E-03	15.2						
142.208	143.142	0.937		2.35E-03	16.2						
143.142	144.079	0.937		1.73E-03	16.3						
144.079	145.016	0.937		1.48E-03	18.0						
145.016	145.716	0.700	QUAD								
146.592	146.948	0.876	DRIFT	1.63E-04	35.6						
146.948	147.468	0.876		2.34E-04	49.7						
147.468	148.344	0.876		1.07E-04	46.9						
148.344	149.219	0.876		1.43E-04	51.3						
149.219	150.065	0.876		3.53E-05	54.2						
150.095	150.571	0.876		4.82E-05	72.9						
150.971	151.847	0.876		4.96E-05	64.4						
151.847	152.197	0.350	QUAD								
152.197	152.547	0.350	QUAD	4.62E-05	92.2	4.81E-05 63.1	2.91E-05 99.0				
152.547	154.347	1.800	RIGHT	3.76E-05	97.1	7.49E-06 98.8	3.41E-05 99.9				
154.347	154.347	3.000	BM								
157.347	158.947	1.600	LEFT	9.34E-05	61.4	1.24E-05 48.6	1.42E-05 45.1	2.72E-06 65.8	2.84E-05 62.4	3.91E-05 49.9	1.02E-06 67.8
158.947	159.647	0.700	QUAD								
159.647	160.747	1.100	RIGHT	7.49E-06	79.5	6.40E-05 68.2	1.23E-05 95.7	1.54E-05 95.9			
160.747	163.747	3.000	BM								
163.747	165.347	1.600	LEFT	7.92E-08	100.0	9.22E-05 56.5	8.09E-07 92.0	1.07E-05 65.8	2.36E-06 65.2	1.30E-06 75.1	9.66E-07 76.7
165.347	166.047	0.700	QUAD								
166.047	166.537	0.490	DRIFT	2.04E-05	89.6	6.37E-07 100.0	3.81E-07 96.8	2.72E-06 100.0			
166.537	166.937	0.400	DRIFT	2.01E-06	97.9	2.86E-06 97.5	3.27E-06 83.0	1.43E-06 100.0			
166.937	167.737	0.800	DRIFT								
167.737	168.536	0.800									
168.536	169.336	0.800									
169.336	169.836	0.500	QUAD								

* circumference is 348.333m

Table 21: Absorbed dose rates at the local shields in the collimator region, the injection septum region, and the extraction septum region

COLLIMATOR Absorbed dose								
Location-range (m)	Length (m)	Absorbed-dose-rate(Gy/sec) Error(%)						
		Detector						
		ConL1	ironL	ironT	ConL2	ironT	ConL2	
11.944	12.644	0.700	6.83E-04	6.8	4.76E-05	8.8	4.89E-05	12.9
14.248	14.948	0.700	2.47E-03	3.7	2.38E-04	4.5	1.96E-04	5.6
16.894	17.594	0.700	9.79E-03	2.3	9.58E-04	2.8	4.09E-04	4.5
17.594	18.294	0.700	1.18E-02	2.1	1.12E-03	2.6	2.08E-04	5.6
18.294	18.894	0.600	1.37E-02	2.1	1.60E-03	2.6	2.81E-04	5.0
20.497	21.197	0.700	1.93E-03	4.1	2.01E-04	5.0	2.18E-04	5.6
23.028	23.728	0.700	2.83E-03	4.3	1.58E-04	6.1	1.14E-04	8.2
25.308	26.008	0.700	1.36E-03	5.3	1.19E-04	6.7	9.27E-05	8.2
27.556	28.056	0.500	4.37E-04	10.4	3.74E-05	14.8	4.49E-05	14.6
29.978	30.678	0.700	5.02E-04	10.1	5.42E-05	11.8	3.02E-05	16.3
33.155	33.955	0.800	1.95E-03	4.7			8.88E-05	9.8

INJECTION Absorbed dose								
Location-range (m)	Length (m)	Absorbed-dose-rate(Gy/sec) Error(%)						
		Detector						
		ConL1	ironL	ironT	ConL2	ironT	ConL2	
-7.559	-6.526	1.033	2.99E-04	2.2	1.21E-05	6.4	1.41E-06	25.4
-6.526	-5.492	1.033	1.00E-03	1.6	6.65E-05	3.7	1.04E-05	16.1
-5.492	-4.459	1.033	1.42E-03	1.9	1.16E-04	2.7	2.87E-05	11.5
-4.459	-3.659	0.800	4.11E-02	0.7	1.74E-03	0.9	1.51E-04	4.7

EXTRACTION Absorbed dose								
Location-range (m)	Length (m)	Absorbed-dose-rate(Gy/sec) Error(%)						
		Detector						
		ConL1	ironL	ironT	ConL2	ironT	ConL2	
124.779	126.354	1.575	9.86E-03	0.3	4.17E-04	0.6	5.33E-05	2.5
126.354	127.929	1.575	8.29E-03	0.4	4.73E-04	0.8	6.30E-05	2.5
127.929	129.504	1.575	2.46E-03	1.0	1.45E-04	1.5	1.84E-05	4.9
129.504	131.079	1.575	8.17E-04	1.9	3.89E-05	2.7	5.25E-06	7.1

11.3 Comparisons with Empirical formulae

In this section, transverse distributions of prompt dose rates from beam line through shield at the injection and the extraction septum in 90 degree direction by the MARS calculation were compared with those by the empirical formulae. Empirical formulae such as Moyer formula [15] can be used in the following conditions,

- distance between beam line and shield wall is about 1 m,
- shield is thick enough that the neutron spectra is in equilibrium state, and
- lateral shield around 90 degree from the beam loss point.

Empirical formulae cannot be applicable for many cases in this 3 GeV RCS calculation such as; 1) collimator region where the beam loss is distributed and the local shields for collimators are complicated structures, 2) the beginning of arc-1 because the hadrons produced in the forward direction from collimators collide the outward shield wall of arc-1, 3) direction except 90 degree from the beam loss point (septums) because of out of conditions.

Calculations using the empirical formulae were carried out for 90 degree of the injection and the extraction septum with the point like beam loss. Following two formulae were used, depending on the proton energy and their parameters and material densities are tabulated in Table 22.

- Tesch's formula [16] for 400 MeV proton at the injection

$$H = J H_{casc} \frac{1}{r^2} \exp\left(-\frac{d}{\lambda}\right) \quad (2)$$

- Moyer formula [15] for 3 GeV proton at the extraction

$$H = J \frac{1}{r^2} H_0 \exp(-b\theta) \exp\left(-\frac{d}{\lambda}\right) \quad (3)$$

H	: prompt dose rate [Sv sec ⁻¹]
J	: proton intensity [proton sec ⁻¹]
H_{casc}	: prompt dose at 1m from the source point [Sv m ²]
r	: distance from the point source [m]
H_0	: extrapolated prompt dose at the source point [Sv m ²]
d	: shield thickness [g cm ⁻²]
λ	: attenuation length [g cm ⁻²]
b	: angular parameter for source [rad ⁻¹]
θ	: angle from beam line [rad]

Table 22: Parameters and material densities used in the empirical formulae

400 MeV injection [16]		3 GeV extraction [17]	
Tesch's formula - Eq.(2)		Moyer formula - Eq.(3)	
J = see Table 1(p.3)			
$H_{casc} = 2.00 \times 10^{-15}$		$H_0 = 2.64 \times 10^{-13}$	
		$b = 2.5$	
λ [g cm ⁻²]		λ [g cm ⁻²]	density [g cm ⁻³]
Concrete	90	143	2.2
Iron	136	188	7.7
Soil	88	139	1.5

Comparison of transverse distributions of prompt dose rates in 90 degree direction between calculation results by the MARS code and by the empirical formulae are shown in Figs. 48 and 49 at the injection septum, and Figs. 50 and 51 at the extraction septum. Although the results by the empirical formulae are shown in the thickness region from beam line to soil, those near the beam line and thinner shield region are meaningless because the empirical formulae give attenuation profiles for the high energy particle and give prompt dose rates behind the thick concrete or soil shield. However, since only high energy part ($E > 20$ MeV) were calculated by the MARS code, both attenuation profiles were very similar. In this comparisons, MARS results were not multiplied by the safety factor (see Table 5, p.34) to compare the results by the empirical formulae. A dose fraction below 20 MeV is taken into account by multiplying the MARS results above 20 MeV by a factor of two. (see Section 9, p.34)

It can be found in the figures that a very good agreement in shape and general features of the dose attenuation in local shielding, concrete and soil calculated with MARS and empirical formula. Especially for the injection region, where only after a very thick soil shielding, the empirical formula starts underestimating the prompt dose reaching a factor of up to five at the ground level. We believe that the geometry details, taken into account in the MARS calculations but not in the empirical approach, are responsible for a somewhat worse situation in the extraction region.

From the results, it can be said that the empirical formulae are useful for rough estimation of prompt dose rate behind a thick shield under the appropriate conditions and their accuracy is a factor of five. Shielding designs for the 3 arcs and the RF section, where MARS calculation was not performed, have been carried out with using the empirical formulae for 90 degree point beam loss at a quadrupole magnet [18].

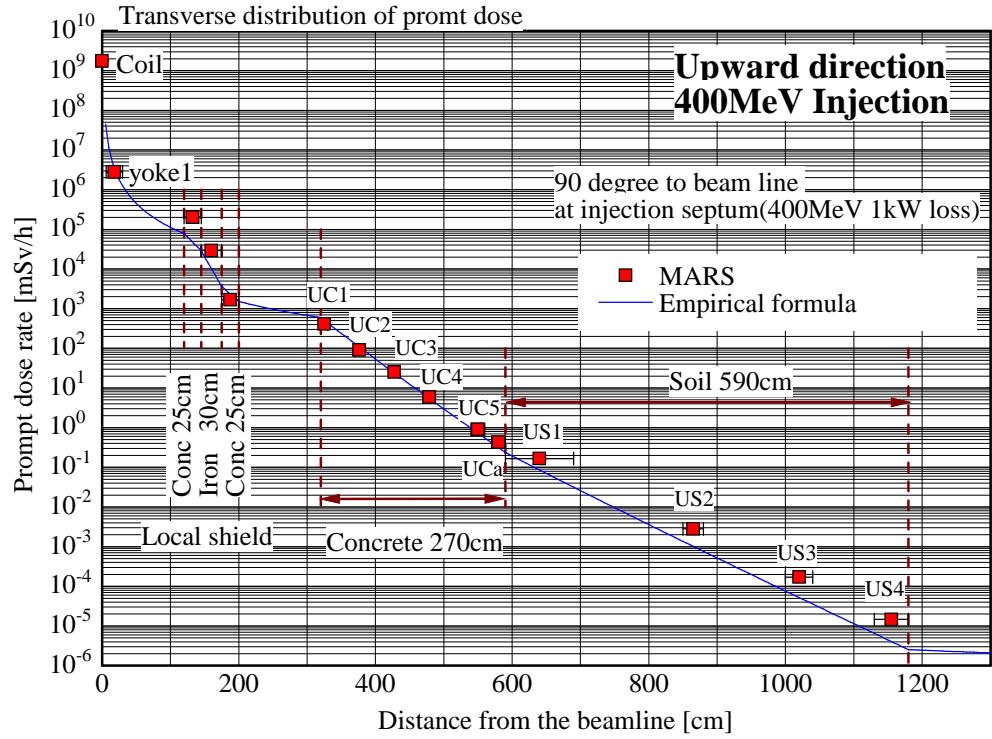


Figure 48: Comparison between the MARS calculation and empirical formula for transverse distributions of prompt dose rates from beam line through shield at injection septum in 90 degree upward direction

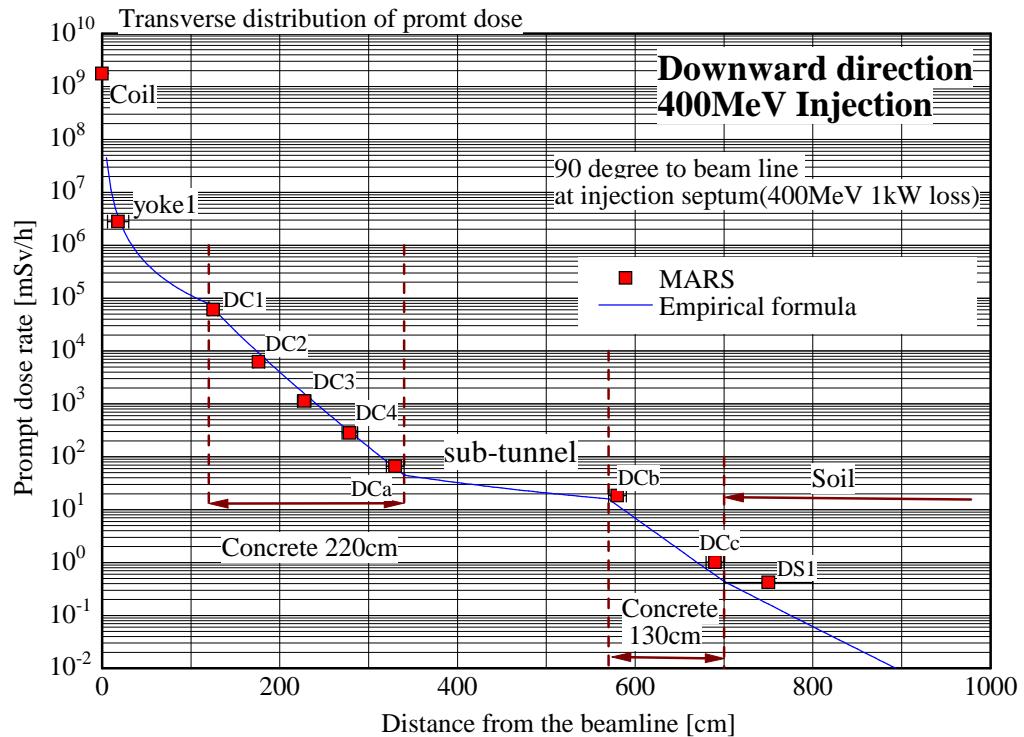


Figure 49: Comparison between the MARS calculation and empirical formula for transverse distributions of prompt dose rates from beam line through shield at injection septum in 90 degree downward direction

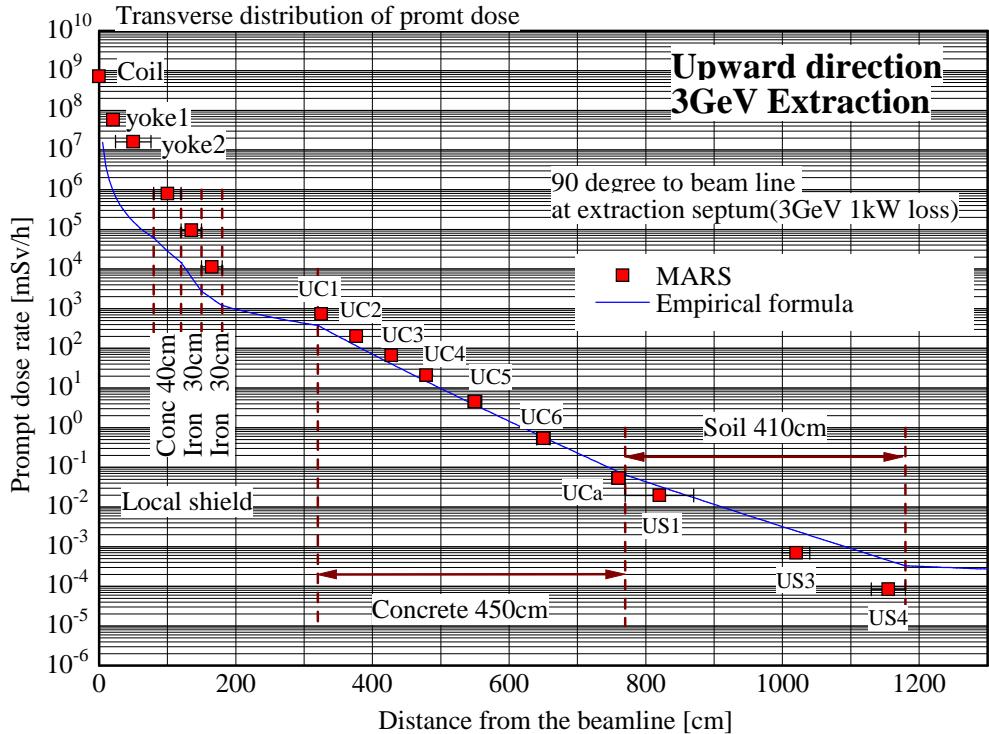


Figure 50: Comparison between the MARS calculation and empirical formula for transverse distributions of prompt dose rates from beam line through shield at extraction septum in 90 degree upward direction

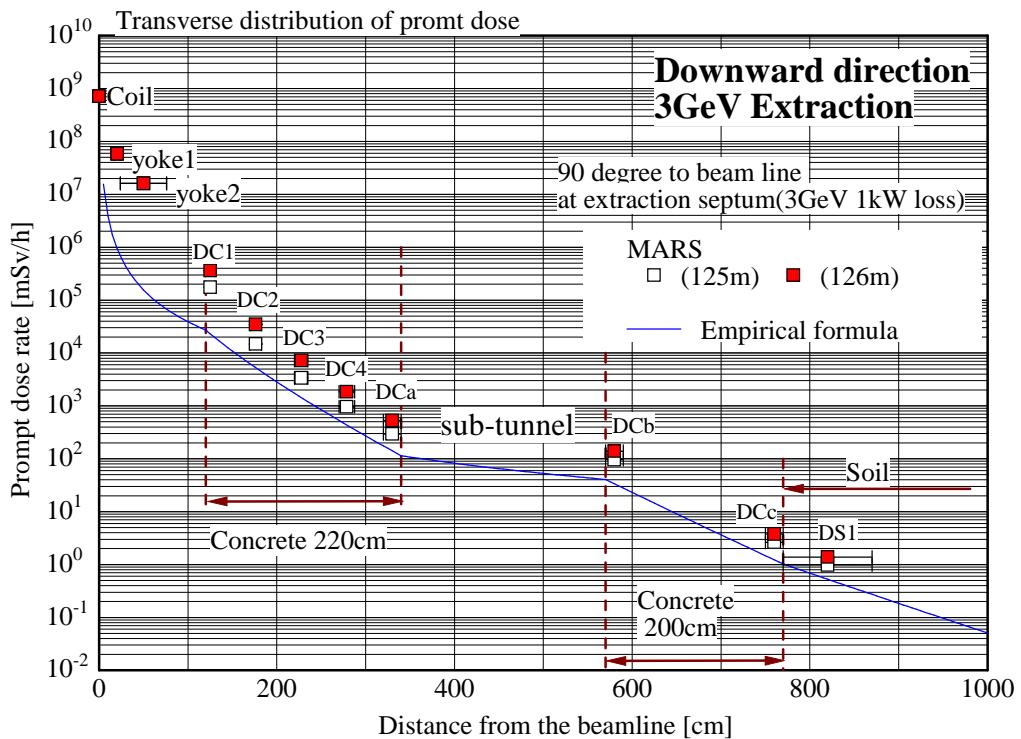


Figure 51: Comparison between the MARS calculation and empirical formula for transverse distributions of prompt dose rates from beam line through shield at extraction septum in 90 degree downward direction

12 SUMMARY

MARS14 Monte-Carlo simulations were performed for collimation and shielding studies of the J-PARC 3-GeV RCS. The beam loss distribution calculated by the STRUCT code was used for collimator region, and local losses of 1 kW each were assumed at the injection and extraction septa. A 3-dimensional multi-layer technique was developed for a deep penetration calculation, and radiation transport through very thick shield with good statistics was carried out by MARS14 code. An effective shielding design was made using the calculated prompt dose rate distributions inside and outside the shield. The residual dose rates at the machine modules and tunnel inner walls were calculated for the estimation of the external exposures. The absorbed dose rates at the beam line modules were also obtained to estimate the radiation damage of beam line materials. This calculation was carried out as a collaborated work with KEK, JAERI and FNAL.

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A INPUT CARDS FOR MARS

Data listed here are available at the following web site;
<http://research.kek.jp/people/noriaki/MARS>

A.1 MARS.INP

```
<JKJ 3GeV-RCS> collimator region using 400MeV-p(1kW) at injection septum-2
/home/mokhov/restricted/mars14/dat
INDX T 4=T 6=F 13=T
CTRL 1
NEVT 1
IPIB 1
ENRG 0.4 0.020
INIT 7=1.0
VARS 4=1.0
NLNG 1
ZSEC 15000.
ZMIN -6000.
NLTR 1
RSEC 20000.
101=0
NMAT 27
MTR 'YOKE' 'COIL' 'CRMC' 'CONC' 'SOIL' 'CU' 'W' 'FE'
'YOKE' 'YOKE' 'YOKE' 'YOKE' 'YOKE' 'YOKE' 'YOKE'
'YOKE' 'YOKE' 'AIR' 'CABL' 'AIR' 'STST' 'FE' 'SOIL'
'FE' 'AL' 'W'
MTDN 4=2.2 1.5 8=7.7 24=1.5
SMIN 0.03 5.
MTSM 4=0.3 0.3 24=0.3
MTSH 4=20 20 24=20
STOP
```

A.2 OPTICS

DRIFT	DRIFT	0.51900	0.51900	0.00000000	0.00000000	0.00000000
QUADRUPOLE	QUAD19	1.01900	0.50000	0.00000000	0.11212000	0.00000000
DRIFT	DRIFT19	1.25900	0.24000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	2.05900	0.80000	0.00000000	0.00000000	0.00000000
DRIFT	BUMP	2.85900	0.80000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	3.65900	0.80000	0.00000000	0.00000000	0.00000000
DRIFT	BUMP	4.45900	0.80000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	4.80900	0.35000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	5.02800	0.21900	0.00000000	0.00000000	0.00000000
QUADRUPOLE	QUAD19	5.92800	0.90000	0.00000000	-0.20001600	0.00000000
DRIFT	DRIFT	10.48700	4.55900	0.00000000	0.00000000	0.00000000
DRIFT	TAR1	11.83700	1.35000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	12.83700	1.00000	0.00000000	0.00000000	0.00000000
DRIFT	COL1	14.18700	1.35000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	15.18700	1.00000	0.00000000	0.00000000	0.00000000
QUADRUPOLE	QUAD	16.08700	0.90000	0.00000000	0.15784200	0.00000000
DRIFT	DRIFT	18.09600	2.00900	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	19.09600	1.00000	0.00000000	0.00000000	0.00000000
DRIFT	COL2	20.44600	1.35000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	21.44600	1.00000	0.00000000	0.00000000	0.00000000
QUADRUPOLE	QUAD19	22.34600	0.90000	0.00000000	-0.20989800	0.00000000
DRIFT	DRIFT	23.74600	1.40000	0.00000000	0.00000000	0.00000000
DRIFT	COL3	25.09600	1.35000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	26.15500	1.05900	0.00000000	0.00000000	0.00000000
DRIFT	COL4	27.50500	1.35000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	28.90500	1.40000	0.00000000	0.00000000	0.00000000
QUADRUPOLE	QUAD	29.60500	0.70000	0.00000000	0.19741400	0.00000000
DRIFT	DRIFT	31.00500	1.40000	0.00000000	0.00000000	0.00000000
DRIFT	COL5	32.35500	1.35000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	35.73600	3.38100	0.00000000	0.00000000	0.00000000
QUADRUPOLE	QUAD	36.08600	0.35000	0.00000000	-0.10686200	0.00000000
QUADRUPOLE	QUAD	36.43600	0.35000	0.00000000	-0.10686200	0.00000000
DRIFT	RIGHT	38.23600	1.80000	0.00000000	0.00000000	0.00000000
SBEND	BM	41.23600	3.00000	0.26179900	0.00000000	0.00000000
DRIFT	LEFT	42.83600	1.60000	0.00000000	0.00000000	0.00000000
QUADRUPOLE	QUAD	43.53600	0.70000	0.00000000	0.23877700	0.00000000
DRIFT	RIGHT	44.63600	1.10000	0.00000000	0.00000000	0.00000000
SBEND	BM	47.63600	3.00000	0.26179900	0.00000000	0.00000000
DRIFT	LEFT	49.23600	1.60000	0.00000000	0.00000000	0.00000000
QUADRUPOLE	QUAD	49.93600	0.70000	0.00000000	-0.23464000	0.00000000
DRIFT	DRIFT	50.42600	0.49000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	50.82600	0.40000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	53.22500	2.39900	0.00000000	0.00000000	0.00000000
QUADRUPOLE	QUAD	53.72500	0.50000	0.00000000	0.15838500	0.00000000
DRIFT	DRIFT	54.16500	0.44000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	54.56500	0.40000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	54.98500	0.42000	0.00000000	0.00000000	0.00000000
QUADRUPOLE	QUAD	55.48500	0.50000	0.00000000	0.15838500	0.00000000
DRIFT	DRIFT	55.97400	0.48900	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	56.37400	0.40000	0.00000000	0.00000000	0.00000000
DRIFT	DRIFT	58.77400	2.40000	0.00000000	0.00000000	0.00000000
QUADRUPOLE	QUAD	59.47400	0.70000	0.00000000	-0.23464000	0.00000000
DRIFT	RIGHT	60.57400	1.10000	0.00000000	0.00000000	0.00000000
SBEND	BM	63.57400	3.00000	0.26179900	0.00000000	0.00000000
DRIFT	LEFT	65.17400	1.60000	0.00000000	0.00000000	0.00000000
QUADRUPOLE	QUAD	65.87400	0.70000	0.00000000	0.23877700	0.00000000
DRIFT	RIGHT	66.97400	1.10000	0.00000000	0.00000000	0.00000000
SBEND	BM	69.97400	3.00000	0.26179900	0.00000000	0.00000000
DRIFT	LEFT	71.57400	1.60000	0.00000000	0.00000000	0.00000000
QUADRUPOLE	QUAD	71.92400	0.35000	0.00000000	-0.10269700	0.00000000
QUADRUPOLE	QUAD	72.27400	0.35000	0.00000000	-0.10269700	0.00000000
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"DRIFT"	"LEFT"	78.67400	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	79.37400	0.70000	0.00000000	0.23877700	0.00000000
"DRIFT"	"RIGHT"	80.47400	1.10000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	83.47400	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	85.07400	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	85.77400	0.70000	0.00000000	-0.23464000	0.00000000
"DRIFT"	"DRIFT"	86.26400	0.49000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	86.66400	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	89.06400	2.40000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	89.56400	0.50000	0.00000000	0.15838500	0.00000000
"DRIFT"	"DRIFT"	90.00400	0.44000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	90.40400	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	90.82300	0.41900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	91.32300	0.50000	0.00000000	0.15838500	0.00000000
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"DRIFT"	"DRIFT"	92.21300	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	94.61200	2.39900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	95.31200	0.70000	0.00000000	-0.23464000	0.00000000
"DRIFT"	"RIGHT"	96.41200	1.10000	0.00000000	0.00000000	0.00000000
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"DRIFT"	"KICKERd"	110.25200	0.14000	0.00000000	0.00000000	0.00000000
"DRIFT"	"KICKERS"	110.95200	0.70000	0.00000000	0.00000000	0.00000000
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"DRIFT"	"KICKERd"	111.95200	0.15000	0.00000000	0.00000000	0.00000000
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"DRIFT"	"KICKERS"	113.40200	0.65000	0.00000000	0.00000000	0.00000000
"DRIFT"	"KICKERd"	113.55200	0.15000	0.00000000	0.00000000	0.00000000
"DRIFT"	"KICKERS"	114.20200	0.65000	0.00000000	0.00000000	0.00000000
"DRIFT"	"KICKERd"	114.34200	0.14000	0.00000000	0.00000000	0.00000000
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"DRIFT"	"DRIFT"	114.85200	0.50000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	115.07100	0.21900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	115.57100	0.50000	0.00000000	0.10986000	0.00000000
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"DRIFT"	"KICKERd"	118.02000	0.14000	0.00000000	0.00000000	0.00000000
"DRIFT"	"KICKERS"	118.72000	0.70000	0.00000000	0.00000000	0.00000000
"DRIFT"	"KICKERd"	118.87000	0.15000	0.00000000	0.00000000	0.00000000
"DRIFT"	"KICKERS"	119.57000	0.70000	0.00000000	0.00000000	0.00000000
"DRIFT"	"KICKERd"	119.72000	0.15000	0.00000000	0.00000000	0.00000000
"DRIFT"	"KICKERS"	120.37000	0.65000	0.00000000	0.00000000	0.00000000
"DRIFT"	"KICKERd"	120.51000	0.14000	0.00000000	0.00000000	0.00000000
"DRIFT"	"KICKER_e"	120.52000	0.01000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	120.92000	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	121.13900	0.21900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	122.03900	0.90000	0.00000000	-0.20001600	0.00000000
"DRIFT"	"DRIFT"	122.27900	0.24000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	125.27900	3.00000	0.00000000	0.00000000	0.00000000
"DRIFT"	"SEPTUMA"	126.17900	0.90000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	126.67900	0.50000	0.00000000	0.00000000	0.00000000
"DRIFT"	"SEPTUMB"	127.57900	0.90000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	128.27900	0.70000	0.00000000	0.00000000	0.00000000
"DRIFT"	"SEPTUMC"	129.17900	0.90000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	129.67900	0.50000	0.00000000	0.00000000	0.00000000
"DRIFT"	"SEPTUD"	130.57900	0.90000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	131.07900	0.50000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	131.29800	0.21900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	132.19800	0.90000	0.00000000	0.15784200	0.00000000
"DRIFT"	"DRIFT"	137.55700	5.35900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	138.45700	0.90000	0.00000000	-0.20989800	0.00000000
"DRIFT"	"DRIFT"	145.01600	6.55900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	145.71600	0.70000	0.00000000	0.19741400	0.00000000
"DRIFT"	"DRIFT"	151.84700	6.13100	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	152.19700	0.35000	0.00000000	-0.10686200	0.00000000
"QUADRUPOLE"	"QUAD"	152.54700	0.35000	0.00000000	-0.10686200	0.00000000
"DRIFT"	"RIGHT"	154.34700	1.80000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	157.34700	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	158.94700	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	159.64700	0.70000	0.00000000	0.23877700	0.00000000
"DRIFT"	"RIGHT"	160.74700	1.10000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	163.74700	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	165.34700	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	166.04700	0.70000	0.00000000	-0.23464000	0.00000000
"DRIFT"	"DRIFT"	166.53700	0.49000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	166.93700	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	169.33600	2.39900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	169.83600	0.50000	0.00000000	0.15838500	0.00000000
"DRIFT"	"DRIFT"	170.27600	0.44000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	170.67600	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	171.09600	0.42000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	171.59600	0.50000	0.00000000	0.15838500	0.00000000
"DRIFT"	"DRIFT"	172.08500	0.48900	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	172.48500	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	174.88500	2.40000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	175.58500	0.70000	0.00000000	-0.23464000	0.00000000
"DRIFT"	"RIGHT"	176.68500	1.10000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	179.68500	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	181.28500	1.60000	0.00000000	0.00000000	0.00000000

"QUADRUPOLE"	"QUAD"	181.98500	0.70000	0.00000000	0.23877700	0.00000000
"DRIFT"	"RIGHT"	183.08500	1.10000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	186.08500	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	187.68500	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	188.03500	0.35000	0.00000000	-0.10269700	0.00000000
"QUADRUPOLE"	"QUAD"	188.38500	0.35000	0.00000000	-0.10269700	0.00000000
"DRIFT"	"RIGHT"	190.18500	1.80000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	193.18500	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	194.78500	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	195.48500	0.70000	0.00000000	0.23877700	0.00000000
"DRIFT"	"RIGHT"	196.58500	1.10000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	199.58500	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	201.18500	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	201.88500	0.70000	0.00000000	-0.23464000	0.00000000
"DRIFT"	"DRIFT"	202.37500	0.49000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	202.77500	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	205.17500	2.40000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	205.67500	0.50000	0.00000000	0.15838500	0.00000000
"DRIFT"	"DRIFT"	206.11500	0.44000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	206.51500	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	206.93400	0.41900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	207.43400	0.50000	0.00000000	0.15838500	0.00000000
"DRIFT"	"DRIFT"	207.92400	0.49000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	208.32400	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	210.72300	2.39900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	211.42300	0.70000	0.00000000	-0.23464000	0.00000000
"DRIFT"	"RIGHT"	212.52300	1.10000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	215.52300	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	217.12300	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	217.82300	0.70000	0.00000000	0.23877700	0.00000000
"DRIFT"	"RIGHT"	218.92300	1.10000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	221.92300	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	223.52300	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	223.87300	0.35000	0.00000000	-0.10269700	0.00000000
"QUADRUPOLE"	"QUAD"	224.22300	0.35000	0.00000000	-0.10269700	0.00000000
"DRIFT"	"DRIFT"	225.16200	0.93900	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	225.83400	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	226.50600	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	227.17800	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	227.67800	0.50000	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	228.35000	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	229.02200	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	229.69400	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	231.18200	1.48800	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	231.68200	0.50000	0.00000000	0.10986000	0.00000000
"DRIFT"	"DRIFT"	232.22200	0.54000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	232.74100	0.51900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	233.24100	0.50000	0.00000000	0.11212000	0.00000000
"DRIFT"	"DRIFT"	233.96400	0.72300	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	234.63600	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	235.30800	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	235.98000	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	237.25000	1.27000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	238.15000	0.90000	0.00000000	-0.20001600	0.00000000
"DRIFT"	"DRIFT"	238.97340	0.82340	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	239.64540	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	240.31740	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	240.98940	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	241.48940	0.50000	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	242.16140	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	242.83340	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	243.50540	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	244.00540	0.50000	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	244.67740	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	245.34940	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	246.02140	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	247.40900	1.38760	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	248.30900	0.90000	0.00000000	0.15784200	0.00000000
"DRIFT"	"DRIFT"	248.71870	0.40970	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	249.39070	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	250.06270	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	250.73470	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	251.23470	0.50000	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	251.90670	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	252.57870	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	253.25070	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	253.66800	0.41730	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	254.56800	0.90000	0.00000000	-0.20989800	0.00000000
"DRIFT"	"DRIFT"	255.54370	0.97570	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	256.21570	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	256.88770	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	257.55970	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	258.05970	0.50000	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	258.73170	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	259.40370	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	260.07570	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	261.12700	1.05130	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	261.82700	0.70000	0.00000000	0.19741400	0.00000000
"DRIFT"	"DRIFT"	262.34870	0.52170	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	263.02070	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	263.69270	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	264.36470	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	264.86470	0.50000	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	265.53670	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	266.20870	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"RF"	266.88070	0.67200	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	267.95800	1.07730	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	268.30800	0.35000	0.00000000	-0.10686200	0.00000000
"QUADRUPOLE"	"QUAD"	268.65800	0.35000	0.00000000	-0.10686200	0.00000000
"DRIFT"	"RIGHT"	270.45800	1.80000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	273.45800	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	275.05800	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	275.75800	0.70000	0.00000000	0.23877700	0.00000000
"DRIFT"	"RIGHT"	276.85800	1.10000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	279.85800	3.00000	0.26179900	0.00000000	0.00000000

"DRIFT"	"LEFT"	281.45800	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	282.15800	0.70000	0.00000000	-0.23464000	0.00000000
"DRIFT"	"DRIFT"	282.64800	0.49000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	283.04800	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	285.44700	2.39900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	285.94700	0.50000	0.00000000	0.15838500	0.00000000
"DRIFT"	"DRIFT"	286.38700	0.44000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	286.78700	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	287.20700	0.42000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	287.70700	0.50000	0.00000000	0.15838500	0.00000000
"DRIFT"	"DRIFT"	288.19600	0.48900	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	288.59600	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	290.99600	2.40000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	291.69600	0.70000	0.00000000	-0.23464000	0.00000000
"DRIFT"	"RIGHT"	292.79600	1.10000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	295.79600	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	297.39600	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	298.09600	0.70000	0.00000000	0.23877700	0.00000000
"DRIFT"	"RIGHT"	299.19600	1.10000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	302.19600	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	303.79600	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	304.14600	0.35000	0.00000000	-0.10269700	0.00000000
"QUADRUPOLE"	"QUAD"	304.49600	0.35000	0.00000000	-0.10269700	0.00000000
"DRIFT"	"RIGHT"	306.29600	1.80000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	309.29600	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	310.89600	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	311.59600	0.70000	0.00000000	0.23877700	0.00000000
"DRIFT"	"RIGHT"	312.69600	1.10000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM"	315.69600	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	317.29600	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	317.99600	0.70000	0.00000000	-0.23464000	0.00000000
"DRIFT"	"DRIFT"	318.48600	0.49000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	318.88600	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	319.88600	1.00000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	320.28598	0.39998	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	320.28599	0.00001	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	320.28600	0.00001	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	320.78600	0.50000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	321.28600	0.50000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	321.78600	0.50000	0.00000000	0.15838500	0.00000000
"DRIFT"	"DRIFT"	322.22600	0.44000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	322.62600	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	323.04500	0.41900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	323.54500	0.50000	0.00000000	0.15838500	0.00000000
"DRIFT"	"DRIFT"	324.03500	0.49000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	324.43500	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	326.83400	2.39900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	327.53400	0.70000	0.00000000	-0.23464000	0.00000000
"DRIFT"	"RIGHT2"	328.63400	1.10000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM2"	331.63400	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT1"	333.23400	1.60000	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD1"	333.93400	0.70000	0.00000000	0.23877700	0.00000000
"DRIFT"	"RIGHT1"	335.03400	1.10000	0.00000000	0.00000000	0.00000000
"SBEND"	"BM1"	338.03400	3.00000	0.26179900	0.00000000	0.00000000
"DRIFT"	"LEFT"	339.63400	1.60000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFTX"	339.63401	0.00001	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	339.98400	0.34999	0.00000000	-0.10269700	0.00000000
"QUADRUPOLE"	"QUAD"	340.33400	0.35000	0.00000000	-0.10269700	0.00000000
"DRIFT"	"DRIFT"	340.57400	0.24000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	341.27400	0.70000	0.00000000	0.00000000	0.00000000
"DRIFT"	"BUMP"	341.67400	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"BUMP"	342.07400	0.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"SEPTUMINJ"	342.87400	0.80000	0.00000000	0.00000000	0.00000000
"DRIFT"	"BUMP"	343.67400	0.80000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	347.07400	3.40000	0.00000000	0.00000000	0.00000000
"DRIFT"	"DRIFT"	347.29300	0.21900	0.00000000	0.00000000	0.00000000
"QUADRUPOLE"	"QUAD"	347.79300	0.50000	0.00000000	0.10986000	0.00000000
"DRIFT"	"DRIFT"	348.33300	0.54000	0.00000000	0.00000000	0.00000000

B SUBROUTINES

All subroutines shown here are available at the following web site;
<http://research.kek.jp/people/noriaki/MARS>

B.1 REG1

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SUBROUTINE REG1(X,Y,Z,N,NIM)
  IMPLICIT DOUBLE PRECISION (A-H,O-Z), INTEGER (I-N)
C.....USER NON-STANDARD GEOMETRY MODULE  REG1
C
C FINDS A ZONE NUMBER "N" AND FILLS MATIND(N) FOR
C A GIVEN POINT IN A NON-STANDARD SECTOR
C N = NFZPEX + M,
C WHERE M IS LOCAL NON-STANDARD ZONE NUMBER DEFINED BY USER
C "M" NEED NOT TO BE A NON-GAP SEQUENCE
C M_MAX - MAXIMUM LOCAL NON-STANDARD ZONE NUMBER DEFINED BY USER !!!
C
C INPUT:
C   X, Y, Z
C   NFZPEX - TOTAL NUMBER OF ZONES IN STANDARD+EXTENDED GEOMETRY
C OUTPUT:
C   N - ZONE NUMBER, NFZPEX < N <= NCELMX <= NTALLY (=50001) !!!
C   N < 0 DEFINES NUMBERED BLACKHOLE (LEAKAGE OUT OF THE SYSTEM)
C   IN NON-STANDARD SECTOR
C   NIM - GEOMETRICAL SUB-SUBREGION NUMBER, 0 < NIM < 1.E6
C   NCELMX - MAXIMUM ZONE NUMBER, NCELMX = NFZPEX + M_MAX <= NTALLY
C   MATIND(N) = MAT
C
C   REVISION: 06-MAR-2001
C
C.....COMMON/BLREG1/INUG,NFZP,NFZPEX,NPL,NZI,NCELMX
SAVE NENTER
DATA NENTER/0/
INCLUDE 'tally1.inc'
COMMON
$      /BLINT1/IBEAM,IO,IEDEP,NTIME,NDAT,NOB,NHSPE,NF,NFZ,NTPL,NDM
$      ,ILEN,NSURF,NTOFF,IPDSUR(12)
$      /BG/E0,ELEAK(3),ELGA,ELEN,ELEAMU,ENEUNO,ALIO(3),BLEAK(3,2)
INCLUDE 'cmasngs.inc'
integer blnzmax
C==== Put actual max local non-standard zone number here !!!
PARAMETER (M_MAX=17000)
C+++ Don't touch !!! ++++++
DIMENSION IMUN(1:M_MAX+1)
DATA IMUN(M_MAX+1)/0/,INCREM/1/
C+++++
C==== Uncomment and define all material indexes (1 to M_MAX)
C==== for non-standard zones here !!!
!     DATA (IMUN(I),I=1,M_MAX)//
```

```

M=0
IF(NENTER.EQ.0) THEN
  call buildbl( 'optics' )
  call seteb1( E0, PM(IO), 83980.492d0 )
  call blmaxmat( blnzmax )
  if ( blnzmax .gt. M_MAX ) then
    write(*,*) 'blnzmax as read from blmatmax', blnzmax
    write(*,*) 'is greater than M_MAX', M_MAX
    stop 'STOP'
  else if ( blnzmax .lt. M_MAX ) then
    write(*,*) 'blnzmax as read from blmatmax', blnzmax
    write(*,*) 'is less than M_MAX', M_MAX
  endif
  if ( blnzmax .gt. 0 ) then
    do i = 1, blnzmax
      call blmat( i, IMUN(I) )
      write(*,*) 'IM=' ,i,IMUN(I)
    enddo
  else
    write(*,*) 'blnzmax is less than 0'
    stop
  endif
  CALL REG3
  NCELMX = NFZPEX+M_MAX
  NENTER=1
  IF(M_MAX.EQ.0) INCREM=-1
  IF(M_MAX.GT.0) THEN
    INUG=1
    WRITE(*,*) 'There are non-standard zones M_MAX= ',M_MAX
    DO L=1,M_MAX,INCREM
      MATIND(NFZPEX+L)=IMUN(L)
    END DO
    NVTEST=1
    CALL VFAN(NVTEST,V)
  ELSE
    INUG=0
    WRITE(*,*) 'There are no non-standard zones in this run !'
    RETURN
  END IF
END IF
C=====
C++ INSERT YOUR NON-STANDARD ZONE NUMBER FINDING ALGORITHM HERE ++
C
mbl = 0
call blgeo( x, y, z, mbl )
m = mbl
C=====

IF(M.GT.0) THEN
  N = NFZPEX+M

```

```

ELSE IF(M.LT.0) THEN          ! Non-standard blackhole
  N = M
END IF
RETURN
END
```

B.2 Goinit

```

subroutine geoinit()
implicit none
include 'tun.inc'
external tun_init_func,
$ tun_geo_func,
$ tun_mat_func,
$ tun_field_func,
$ tun_vol_func
external bend_name_func,
$ bend_init_func,
$ bend_geo_func,
$ bend_mat_func,
$ bend_field_func,
$ bend_vol_func
external drift_name_func,
$ driftx_name_func,
drift_init_func,
drift_geo_func,
driftx_geo_func,
drift_mat_func,
drift_field_func,
drift_vol_func
external drift10_name_func,
$ drift10_init_func,
drift10_geo_func,
drift10_mat_func,
drift10_field_func,
drift10_vol_func
external drift_left_name_func,
$ drift_left_init_func,
drift_left_geo_func
external drift_right_name_func,
$ drift_right_init_func,
drift_right_geo_func
external quadru_name_func,
$ quadru19_name_func,
quadru_init_func,
quadru_geo_func,
quadru19_geo_func,
quadru_mat_func,
quadru_field_func,
quadru19_field_func,
quadru_vol_func,
quadru19_vol_func
external septum_a_name_func,
$ septum_b_name_func,
septum_c_name_func,
septum_d_name_func,
septum_inj_name_func,
septum_init_func,
septum_a_geo_func,
septum_b_geo_func,
septum_c_geo_func,
septum_d_geo_func,
septum_inj_geo_func,
septum_mat_func,
septum_field_func,
septum_a_vol_func,
septum_b_vol_func,
septum_c_vol_func,
septum_d_vol_func,
septum_inj_vol_func
external kicker_l_name_func,
$ kicker_s_name_func,
kicker_init_func,
kicker_l_geo_func,
kicker_s_geo_func,
kicker_mat_func,
kicker_field_func,
kicker_l_vol_func,
kicker_s_vol_func
external kicker_d_name_func,
$ kicker_d_init_func,
kicker_d_geo_func,
kicker_d_mat_func,
kicker_d_field_func,
kicker_d_vol_func
external kicker_e_name_func,
$ kicker_e_init_func,
kicker_e_geo_func,
kicker_e_mat_func,
kicker_e_field_func,
kicker_e_vol_func
external rf_name_func,
$ rf_init_func,
rf_geo_func,
rf_mat_func,
rf_field_func,
rf_vol_func
external col_1_name_func,
$ col_2_name_func,
$ col_3_name_func,
$ col_4_name_func,
$ col_5_name_func,
tar_1_name_func,
col_init_func,
col_1_geo_func,
col_2_geo_func,
col_3_geo_func,
col_4_geo_func,
col_5_geo_func,
tar_1_geo_func,
col_mat_func,
$ col_field_func,
$ col_vol_func
external bump_name_func,
$ bump_init_func,
$ bump_geo_func,
$ bump_mat_func,
$ bump_field_func,
$ bump_vol_func
call tunnel_register( 11000,
$ tunnel_h_shift,
$ tunnel_v_shift,
$ tun_init_func,
$ tun_geo_func,
$ tun_mat_func,
$ tun_field_func,
$ tun_vol_func)
call mars_el_register( 1, !"DRIFT"
2,
$ drift_name_func,
drift_init_func,
drift_geo_func,
drift_mat_func,
drift_field_func,
drift_vol_func )
call mars_el_register( 2, !"BM"
29, ! max zone numbers
bend_name_func,
bend_init_func,
bend_geo_func,
bend_mat_func,
bend_field_func,
bend_vol_func )
call mars_el_register( 3, !"QUAD"
34,
$ quadru_name_func,
quadru_init_func,
quadru_geo_func,
quadru_mat_func,
quadru_field_func,
quadru_vol_func )
call mars_el_register( 4, !"LEFT"
2,
$ drift_left_name_func,
drift_left_init_func,
drift_left_geo_func,
drift_mat_func,
drift_field_func,
drift_vol_func )
call mars_el_register( 5, !"RIGHT"
2,
$ drift_right_name_func,
drift_right_init_func,
drift_right_geo_func,
drift_mat_func,
drift_field_func,
drift_vol_func )
call mars_el_register( 6, !"KICKERL"
5,
$ kicker_l_name_func,
kicker_init_func,
kicker_l_geo_func,
kicker_mat_func,
kicker_field_func,
kicker_l_vol_func )
call mars_el_register( 7, !"KICKERS"
5,
$ kicker_s_name_func,
kicker_init_func,
kicker_s_geo_func,
kicker_mat_func,
kicker_field_func,
kicker_s_vol_func )
call mars_el_register( 8, !"SEPTUMA"
10,
$ septum_a_name_func,
septum_init_func,
septum_a_geo_func,
septum_mat_func,
septum_field_func,
septum_a_vol_func)
call mars_el_register( 9, !"SEPTUMB"
10,
$ septum_b_name_func,
septum_init_func,
septum_b_geo_func,
septum_mat_func,
septum_field_func,
septum_b_vol_func )
call mars_el_register( 10, !"SEPTUMC"
10,
$ septum_c_name_func,
septum_init_func,
septum_c_geo_func,
septum_mat_func,
septum_field_func,
septum_c_vol_func )
call mars_el_register( 11, !"SEPTUMD"
10,
$ septum_d_name_func,
septum_init_func,
septum_d_geo_func,
septum_mat_func,
septum_field_func,
septum_d_vol_func )
call mars_el_register( 12, !"SEPTUMINJ"

```

```

$      10,
$      septum_inj_name_func,
$      septum_init_func,
$      septum_inj_geo_func,
$      septum_mat_func,
$      septum_field_func,
$      septum_inj_vol_func )
call mars_el_register( 14,          !"RF"
$      6,
$      rf_name_func,
$      rf_init_func,
$      rf_geo_func,
$      rf_mat_func,
$      rf_field_func,
$      rf_vol_func )
call mars_el_register( 15,          !"BUMP"
$      6,
$      bump_name_func,
$      bump_init_func,
$      bump_geo_func,
$      bump_mat_func,
$      bump_field_func,
$      bump_vol_func )
call mars_el_register( 16,          !"KICKERd"
$      2,
$      kicker_d_name_func,
$      kicker_d_init_func,
$      kicker_d_geo_func,
$      kicker_d_mat_func,
$      kicker_d_field_func,
$      kicker_d_vol_func )
call mars_el_register( 17,          !"KICKER_e"
$      2,
$      kicker_e_name_func,
$      kicker_e_init_func,
$      kicker_e_geo_func,
$      kicker_e_mat_func,
$      kicker_e_field_func,
$      kicker_e_vol_func )
call mars_el_register( 18,          !"COL1"
$      180,
$      col_1_name_func,
$      col_init_func,
$      col_1_geo_func,
$      col_mat_func,
$      col_field_func,
$      col_vol_func )
call mars_el_register( 19,          !"QUAD19"
$      34,
$      quadru19_name_func,
$      quadru_init_func,
$      quadru19_geo_func,
$      quadru19_mat_func,
$      quadru19_field_func,
$      quadru19_vol_func )
call mars_el_register( 20,          !"DRIFT19"
$      2,
$      drift10_name_func,
$      drift10_init_func,
$      drift10_geo_func,
$      drift10_mat_func,
$      drift10_field_func,
$      drift10_vol_func)
call mars_el_register( 22,          !"DRIFTX"
$      2,
$      driftx_name_func,
$      driftx_init_func,
$      driftx_geo_func,
$      driftx_mat_func,
$      driftx_field_func,
$      driftx_vol_func )
call mars_el_register( 26,          !"COL2"
$      180,
$      col_2_name_func,
$      col_init_func,
$      col_2_geo_func,
$      col_mat_func,
$      col_field_func,
$      col_vol_func )
call mars_el_register( 27,          !"COL3"
$      180,
$      col_3_name_func,
$      col_init_func,
$      col_3_geo_func,
$      col_mat_func,
$      col_field_func,
$      col_vol_func )
call mars_el_register( 28,          !"COL4"
$      180,
$      col_4_name_func,
$      col_init_func,
$      col_4_geo_func,
$      col_mat_func,
$      col_field_func,
$      col_vol_func )
call mars_el_register( 29,          !"COLS"
$      180,
$      col_5_name_func,
$      col_init_func,
$      col_5_geo_func,
$      col_mat_func,
$      col_field_func,
$      col_vol_func )
call mars_el_register( 30,          !"TAR1"
$      180,
$      tar_1_name_func,
$      col_init_func,
$      tar_1_geo_func,
$      col_mat_func,
$      col_field_func,
$      col_vol_func )
return
end

```

B.3 Tunnel Structure

B.3.1 tun.f

```

* JHP 3 GeV tunnel
*
* March 2001 by NVM
* Modified May 10, 2001
* Changed for other tunnel 12-MAY-2001
* changed Nakao 6-June-2001
*
subroutine tun_init_func()
implicit none
return
end

subroutine tun_geo_func(pos0,pos,x,y,z,nz)
C== pos0 is the initial beam element position relative
C      to the MAD beamline (starting point in optics) ===
C== pos  is the absolute beam element position relative
C      to the MAD beamline (optics) === 18-MAY-2001 by kriol
C
implicit none
integer nz,nzt,nzd,nzx,ioutflag
integer ii,jj,nzmax1,id
double precision x,y,z,ps,ps0
double precision zp,zp1
include 'tun.inc'
INTEGER NENTER,NENTER1,NENTER2
double precision ztt
double precision det_length
double precision zsta
common /ZSTA/zsta,NENTER1
DATA NENTER,NENTER2/0,0/
SAVE NENTER,NENTER2
IF (NENTER.EQ.0) THEN
    NENTER = 1
    zstart=ps0
ENDIF
IF ((NENTER1.EQ.1).and.(NENTER2.EQ.0)) THEN
    NENTER2=1
    write(*,*)
% 'zstart BEG1,REG1 : ', zsta,zstart,abs(zsta - zstart)
    write(44,*)
% 'zstart BEG1,REG1 : ', zsta,zstart,abs(zsta - zstart)
    if (abs(zsta - zstart) .gt. 0.01d0) then
        write(*,*) 'zsta and zstart are NOT equal'
        write(44,*) 'zsta and zstart are NOT equal'
        stop
    endif
ENDIF
zp=zstart
zp1=zp
if (zp.lt.0.0d0) zp=zp1+tun_length
if (zp.gt.tun_length) zp=zp1-tun_length
nz=0
call tun_geo_main(x,y,zp,nzt,nzd) ! tunnel geometry
ioutflag=0
call xyout(x,y,zp,ioutflag)
if (ioutflag.eq.1) return
if ((x.gt.mt_b).and.(x.lt.mt_t).and.
& (y.gt.mt_l).and.(y.lt.mt_r))
& call tun_geo_extend(x,y,zp,nz) ! local shield
if (nz.gt.0) return
if (nz.eq.0) then
    if (nzt.le.0) return
    do id=1,n_tun_div
        if (zp.le.tun_div(id)) goto 43
    enddo
    id=n_tun_div
43   nz=nzt+(id-1)*ibdet
    return
endif
nzmax1=0
do ii=1,n_tun_reg
    if (zp.le.tun_reg(ii)) goto 44
    nzmax1=nzmax1+num_subp(ii)*(num_det+num_extreg(ii))
enddo
ii=n_tun_reg
44   continue
det_length=(tun_reg(ii)-tun_reg(ii-1))/DBLE(num_subp(ii))
do jj=1,num_subp(ii)
    ztt=tun_reg(ii-1)+det_length*jj
    if (zp.le.ztt) goto 55
enddo
jj=num_subp(ii)
55   nz=nzd +(num_det+num_extreg(ii))*(jj-1)
$     +nzmax1
$     +ibdet*n_tun_div
return
end

subroutine tun_geo_main(x,y,zp,nzt,nzd)
integer nzt,nzd
double precision x,y,zp
include 'tun.inc'

c 0-10m
    if (zp.le.1000.0d0) then      !inj1
        call tun_geo_inj(x,y,zp,nzt,nzd)
        return
    endif
c 10-15m
    if (zp.le.1500.0d0) then      !inj to col 1
        call tun_geo_injcol1(x,y,zp,nzt,nzd)
        return
    endif
c 15-17.5m
    if (zp.le.1750.0d0) then      !inj to col 2
        call tun_geo_injcol2(x,y,zp,nzt,nzd)
        return
    endif
c 17.5-32m
    if (zp.le.3200.0d0) then      !col
        call tun_geo_col(x,y,zp,nzt,nzd)
        return
    endif
c 32-37.236m
    if (zp.le.3723.6d0) then      !col -> arc1 a
        call tun_geo_colarc1a(x,y,zp,nzt,nzd)
        return
    endif
c 37.236-38.236m
    if (zp.le.3823.6d0) then      !col -> arc1 a1
        call tun_geo_colarc1a1(x,y,zp,nzt,nzd)
        return
    endif
c 38.236-50m
    if (zp.le.5000.0d0) then      !col -> arc1 b
        call tun_geo_colarc1b(x,y,zp,nzt,nzd)
        return
    endif
c 50-69.9740m
    if (zp.le.6997.40d0) then      !col -> arc1 b1
        call tun_geo_colarc1b1(x,y,zp,nzt,nzd)
        return
    endif
c 69.9740-10581.2m
    if (zp.le.10581.2d0) then      !Arc1
        call tun_geo_arc(x,y,zp,nzt,nzd)
        return
    endif
c 105.812-118.6m
    if (zp.le.11860.0d0) then      !kicker
        call tun_geo_kick(x,y,zp,nzt,nzd)
        return
    endif
c 118.8-120.6m
    if (zp.le.12060.0d0) then      !kicker->exsp
        call tun_geo_kickexsp(x,y,zp,nzt,nzd)
        return
    endif
c 120.6-134.0m
    if (zp.le.13400.0d0) then      !exsp
        call tun_geo_exsp(x,y,zp,nzt,nzd)
        return
    endif
c 134.-142m
    if (zp.le.14100.0d0) then      !exsp
        call tun_geo_exsp_a(x,y,zp,nzt,nzd)
        return
    endif
c 141-142m
    if (zp.le.14200.0d0) then      !exsp -> exsp1
        call tun_geo_exsp_a1(x,y,zp,nzt,nzd)
        return
    endif
c 142-155.847m
    if (zp.le.15584.7d0) then      !exsp -> arc2 1
        call tun_geo_extrarc2_1(x,y,zp,nzt,nzd)
        return
    endif
c 155.847-157.347m
    if (zp.le.15734.7d0) then      !arc2 entrance
        call tun_geo_arc2_entrance(x,y,zp,nzt,nzd)
        return
    endif
c 157.347-163.747m
    if (zp.le.16374.7d0) then      !exsp -> arc2 2
        call tun_geo_extrarc2_2(x,y,zp,nzt,nzd)
        return
    endif
c 163.747-212.523m
    if (zp.le.21252.3d0) then      !arc2
        call tun_geo_arc(x,y,zp,nzt,nzd)
        return
    endif
c 212.523-218.923m
    if (zp.le.21892.3d0) then      !arc2 -> RF 1

```

```

    call tun_geo_arc2rf_1(x,y,zp,nzt,nzd)
    return
  endif
c
c 218.923-221.923m
  if (zp.le.22192.3d0) then !arc2 -> RF 2
    call tun_geo_arc2rf_2(x,y,zp,nzt,nzd)
    return
  endif
c
c 221.923-270.458m
  if (zp.le.27045.8d0) then !RF
    call tun_geo_rf(x,y,zp,nzt,nzd)
    return
  endif
c
c 270.458-273.458m
  if (zp.le.27345.8d0) then !RF->Arc3 1
    call tun_geo_rfarc3_1(x,y,zp,nzt,nzd)
    return
  endif
c
c 275.408-279.858m
  if (zp.le.27985.8d0) then !RF->Arc3 2
    call tun_geo_rfarc3_2(x,y,zp,nzt,nzd)
    return
  endif
c
c 279.858-324m
  if (zp.le.32400.0d0) then !arc3
    call tun_geo_arc(x,y,zp,nzt,nzd)
    return
  endif
c
c 324-328.634m
  if (zp.le.32863.4d0) then !arc3 -> crane 2
    call tun_geo_arc3cran_2(x,y,zp,nzt,nzd)
    return
  endif
c
c 328.634-339.984m
  if (zp.le.33998.4d0) then !crane
    call tun_geo_cran(x,y,zp,nzt,nzd)
    return
  endif
c
c 339.984-340.984m
  if (zp.le.34098.4d0) then !crane -> injection1
    call tun_geo_craninj1(x,y,zp,nzt,nzd)
    return
  endif
c
c 340.984-348.333m
  if (zp.le.34833.3d0) then !crane -> injection2
    call tun_geo_craninj2(x,y,zp,nzt,nzd)
    return
  endif
return
end

subroutine tun_geo_extend(x,y,zp,nz)
include 'tun.inc'
integer nz,nnn
double precision x,y,zp
double precision za1,za2,za3,za4
nnn=num_tunpartreg ! number of standard tunnel partition region
***** local shield at extraction septum *****
za1= 12477.9d0
za2= 13107.9d0
za3= 13580.0d0
za4= 13700.0d0
if ((zp.ge.za1).and.(zp.le.za2)).or.
% ((zp.ge.za3).and.(zp.le.za4))) then
  call localshield_geo_ext(x,y,zp,nz,za1,za2,za3,za4,nnn)
endif
nnn=nnn+6      ! add a number of regions of local shield
if (nz.gt.0) return

***** local shield at injection septum *****
za1= 34077.4d0
za2= 34467.4d0
if ((zp.ge.za1).and.(zp.le.za2)) then
  call localshield_geo_injsept(x,y,zp,nz,za1,za2,nnn)
endif
nnn=nnn+3      ! add a number of regions of local shield
if (nz.gt.0) return

***** local shield at collimator region *****
call localshield_geo_coli(x,y,zp,nz,nnn)
nnn=nnn+n_col_locals*2 ! add a number of regions of local shield
if (nz.gt.0) return
end

subroutine tun_field_func( x, y, z, bx, by, bz, bbb )
implicit none
double precision x, y, z, bx, by, bz, bbb
bx = 0.0d0
by = 0.0d0
bz = 0.0d0
bbb = 0.0d0
return
end

```

```

subroutine tun_vol_func(nz,volume)
implicit none
include 'consts.inc'
include 'tun.inc'
integer nz,ii,jj,kk,n1,nnn,nenter,kj,nzmax
double precision volume,det_length
double precision aai,dz,dv,dlz
integer iv,jz,ireg,nzz
integer i,j,jjmax,integreg,ntundiv
double precision dvol,dth
double precision zw(2),blength(n_det),zend
integer kb
double precision bmlparams,pos0,length,bbl
external bmlparams
double precision tun_vol(tun_no_of_zones)
data tun.vol/tun_no_of_zones*0.0d0/
DATA NENTER/0/
integer iunit
DATA iunit/33/
SAVE NENTER
save tun.vol
IF ( NENTER .EQ. 0 ) THEN
  NENTER=1
  open(iunit,file='REGTUNNEL')
  write(iunit,19)
  19  format('Division-No. ibdet',9x,11x,3x,10x,7x,
  & 'grand-integ-region')
  integreg=0
  do j=1,n_tun_div
    integreg=integreg+ibdet
    write(iunit,18) j,ibdet,integreg
  18  format(i9,i12,9x,11x,3x,10x,i1x,i10)
  enddo
  ntundiv=integreg
  write(iunit,20)
  20  format('Partition-No. num_det num_subp num_extreg',
  & 3x,' nmax int_nmax grand-integ-region')
  & int_nmax(0)=0.0d0
  do ii=1,n_tun_reg
    nzmax(ii)=num_subp(ii)*(num_det+num_extreg(ii))
    int_nmax(ii)=int_nmax(ii-1)+nzmax(ii)
    integreg=integreg+nzmax(ii)
    write(iunit,21) ii,num_det,num_subp(ii),
    & num_extreg(ii),nzmax(ii),int_nmax(ii),integreg
  21  format(i9,i12,i9,i11,3x,i10,i11,i10)
  enddo
  num_tunpartreg=int_nmax(n_tun_reg)+n_tun_div*ibdet
  pos0=bmlparams( 1 )
  length=bmlparams( 2 )
  zend=pos0+length
c
  zend: end z-position of tunnel
  if (zend.gt. tun_length ) zend=tun_length
  write(iunit,*) 'pos0,length,zend',pos0,length,zend
  close(iunit)
*****
* Define VOLUME
*****
c
  nzmax1=0
  do ii=1,n_tun_reg
    det_length=(tun_reg(ii)-tun_reg(ii-1))/DBLE(num_subp(ii))
    do jj=0,num_subp(ii)-1
      if (ibdet(ii).eq.1) then
        zw(1)=tun_reg(ii-1)+det_length*jj
        zw(2)=zw(1)+det_length
        if (((zend.gt.pos0).and.
        & ((zw(1).ge.pos0).and.(zw(2).le.zend))).or.
        & ((zend.lt.pos0).and.
        & ((zw(2).le.zend).or.(zw(1).ge.pos0)))) then
          call bendlength(zw,blength,ii)
        else
          do kb=1,n_det
            blength(kb)=0.0d0
          enddo
        endif
      else
        do kb=1,n_det
          blength(kb)=det_length
        enddo
      endif
      jjmax=jj*(num_det+num_extreg(ii))+int_nmax(ii-1)+ntundiv
    c tunnel detector (n_det) nzd=1-8
      do i=1,n_tun_det
        kb=i
        n1=jjmax+i
        if ((i.eq.7).or.(i.eq.8)) then !sub-tunnel
c
        sub-tunnel detector
          tun.vol(n1)=
          $ soil_det_thick*soil_det_width*2.0d0*blength(kb)
          else
c
        main-tunnel detector
          tun.vol(n1)=
          $ tun_det_thick*tun_det_width*2.0d0*blength(kb)
          endif
        enddo
c
        soil detector nzd=9-18
        do i=1,10
          kb=i + n_tun_det
          n1=jjmax+kb
          if (i.le.4)
          $ tun.vol(n1)=soil_det_thick*soil_det_width*2.0d0*blength(kb)
          if ((i.ge.5).and.(i.le.6))
          $ tun.vol(n1)=soil_det1_thick**2.0d0 *2.0d0*blength(kb)
          if (i.ge.7)
        end
      endif
    end
  end
end

```

```

$ tun_vol(n1)=soil_det1_thick*soil_det1_width*2.0d0*blength(kb)
    enddo

c vertical detector   nzd=19-121
    do i=1,n_vert_det
        n1=jjmax+n_det+i
        tun_vol(n1)=vert_det_thick(i)
    $ *vert_det_width(i)*2.0d0*det_length
    enddo
c extra detector   nzd=18-37
    do i=1,num_extreg(ii)
        n1=jjmax+n_det+n_vert_det+i
        tun_vol(n1)=tun_indet_thick(i)
    $ *tun_indet_width(i)*2.0d0*det_length
    enddo
    enddo
ENDIF
volume = 0.0d0
if ( nz .ge. 1 .and. nz .le. tun_no_f_zones ) then
    volume = tun_vol(nz)
endif
write(65,109) nz,volume
109 format('nz=',i5,1pe11.3)
return
end

* inner & outer length estimation at bending region
*
subroutine bendlength(zw,blength,ii)
implicit none
include 'tun.inc'
double precision z,pos(3),dir(3)
double precision yw(n_det),ywp(2),zwp(2)
double precision zw(2),blength(n_det)
integer ib,kb,n01,n02,NENTER,ii
double precision bmlparams, pos0,length
external bmlparams
DATA NENTER/0/
SAVE NENTER
IF ( NENTER .EQ. 0 ) THEN
    NENTER=1
    open(23,file='LENGTH_BEND')
    write(23,122)
122 format('Detector Length Estimation at Bending Section')
    pos0=bmlparams( 1 )
    length=bmlparams( 2 )
ENDIF
write(23,120) ii,zw(1),zw(2)
120 format('No.',i4,3x,'z=',0p2f10.2)
zw(1)=zw(1)+0.01
zw(2)=zw(2)+0.01
do kb=1,n_det
    yw(kb)=0.0d0
enddo
do ib=1,2
    zw(ib)
c estimate mtw_r,mt_r,mt_l,mtw_l for z-value
    call tun_geo_main(0.0d0, 0.0d0, z, n01, n02)
    yw( 1)=0.0d0
    yw( 2)=yw( 2) + (mt_l + tun_det_side)/2.0d0
    yw( 3)=yw( 3) + mt_l/2.0d0 - tun_det_thick/4.0d0
    yw( 4)=yw( 4) + (mt_l + tun_det_side)/2.0d0
    yw( 5)=0.0d0
    yw( 6)=yw( 6) + mt_r/2.0d0 + tun_det_thick/4.0d0
    yw( 7)=0.0d0
    yw( 8)=0.0d0
    yw( 9)=0.0d0
    yw(10)=yw(10) + mtw_l/2.0d0 - soil_det_thick/4.0d0
    yw(11)=0.0d0
    yw(12)=yw(12) + mtw_r/2.0d0 + soil_det_thick/4.0d0
    yw(13)=yw(13) + stw_l/2.0d0 - soil_det_thick/4.0d0
    yw(14)=yw(14) + stw_r/2.0d0 + soil_det_thick/4.0d0
enddo
do kb=1,n_det
    do ib=1,2
        dir(1)=0.d0
        dir(2)=0.d0
        dir(3)=1.d0
        pos(1)=0.0d0
        pos(2)=yw(kb)
        if (zw(ib).gt.pos(2)) then
            pos(3)=zw(ib)-pos(0)
        else
            pos(3)=zw(ib)-pos(0)+tun_length
        endif
        call flat2glob(pos,dir)
        ywp(ib)= pos(2)
        zwp(ib)= pos(3)
    enddo
    blength(kb)=sqrt((zwp(1)-zwp(2))*2+(ywp(1)-ywp(2))*2)
    write(23,121) kb,zwp(1),ywp(1),zwp(2),ywp(2),blength(kb)
121 format(i3,20p2f10.2,2x),f13.2)
enddo
return
end

block data tun_db
implicit none
include 'tun.inc'
integer i
data tunnel_h_shift/0.0d0,
& tunnel_v_shift/0.0d0,

```

```

& tun_length /34833.3d0/
data mt_b/-120.0d0,
& st_b/-570.0d0/
data tun_rd_th/30.0d0,
& tun_dp_th/180.0d0,
& tun_dp_thia/90.0d0,
& soil_dp_th/250.0d0/
data outer_soil_t / 1180.0d0,
& outer_soil_b / -900.0d0/,
& outer_soil_r / 1300.0d0/,
& outer_soil_l /-1100.0d0/,
& air_thick /200.0d0/
data tun_det_thick / 10.0d0,
& tun_det_width / 50.0d0,
& tun_det_side / 80.0d0,
& soil_det_thick/ 20.0d0,
& soil_det_width/150.0d0,
& soil_det1_thick/100.0d0/,
& soil_det1_width/250.0d0/
data zcran/34400.0d0/
**** detector between tunnel and soil (extreg)
C upward
    data (tun_indet_dist(i), i=1,iext) !5
    & /50.0d,100.0d,150.0d,220.0d,320.0d/ !position
    data (tun_indet_thick(i),i=1,iext)
    & /12.5d0, 15.0d, 17.5d0, 20.0d, 20.0d/
    data (tun_indet_width(i),i=1,iext)
    & / 75.0d, 100.0d, 125.0d, 150.0d, 150.0d/
C right
    data (tun_indet_dist(i), i=iext+1,iext) !4
    & /50.0d,100.0d,150.0d,200.0d/ !,250.0d/ !position
    data (tun_indet_thick(i),i=iext+1,iext)
    & /12.5d0, 15.0d,17.5d0, 20.0d/ !, 20.0d/
    data (tun_indet_width(i),i=iext+1,iext)
    & / 75.0d,100.0d,125.0d/ !,150.0d/
C downward
    data (tun_indet_dist(i), i=iext+1,iextd) / 50.0d,100.0d,150.0d/
    data (tun_indet_thick(i),i=iext+1,iextd) / 12.5d0,15.0d,17.5d0/
    data (tun_indet_width(i),i=iext+1,iextd) / 75.0d,100.0d,125.0d/
C left
    data (tun_indet_dist(i), i=iextd+1,iextl) !4
    & /50.0d,100.0d,150.0d,200.0d/ !,250.0d/
    data (tun_indet_thick(i),i=iextd+1,iextl)
    & /12.5d0, 15.0d,17.5d0, 20.0d/ !, 20.0d/
    data (tun_indet_width(i),i=iextd+1,iextl)
    & / 75.0d,100.0d,125.0d/ !,150.0d/
c vertical detector
c           ! vertical position [cm] of detector
    data vert_det_height/850.0d0,1000.0d0,1130.0d0/
    data vert_det_thick / 30.0d0, 40.0d0, 50.0d0/
    data vert_det_width /300.0d0, 400.0d0, 500.0d0/
*****
***** Tunnel division boundary
*****
    data tun_div/
    $ 3608.6d0, 7192.4d0, 11611.1d0, 15219.7d0,
    $ 18803.5d0, 22387.3d0, 26830.8d0, 30414.6d0, 34833.3d0/
*****
***** Tunnel detector partition boundary
*****
c
c tun_reg
    DATA tun_reg/ ! boudary[cm] of partition
    $ 0.0000D0, 1000.0000D0, 1500.0000D0, 1750.0000D0, 3823.600D0,
    $ 4123.600D0, 4463.600D0, 4763.600D0, 5000.000D0, 6057.400D0,
    $ 6357.400D0, 6697.400D0, 6997.400D0, 7407.400D0, 7707.400D0,
    $ 8047.400D0, 8347.400D0, 9641.200D0, 9941.200D0, 10281.200D0,
    $ 10581.200D0, 11860.000D0, 12060.000D0, 13400.000D0, 14100.000D0,
    $ 14200.000D0, 15434.700D0, 15734.700D0, 16074.700D0, 16374.700D0,
    $ 17668.500D0, 17968.500D0, 18308.500D0, 18608.500D0, 19018.500D0,
    $ 19318.500D0, 19658.500D0, 19958.500D0, 21252.300D0, 21552.300D0,
    $ 21892.300D0, 22192.300D0, 27045.800D0, 27345.800D0, 27685.800D0,
    $ 27985.800D0, 29279.600D0, 29579.600D0, 29919.600D0, 30219.600D0,
    $ 30629.600D0, 30929.600D0, 31269.600D0, 31569.600D0, 32400.000D0,
    $ 32863.400D0, 33163.400D0, 33503.400D0, 33803.400D0, 33998.400D0,
    $ 34098.400D0, 34833.300D0/
    DATA num_subp/ ! number of detector-subpartition in a partition
    $ 10, 5, 3, 21, 2, 3, 2, 2, 9, 2,
    $ 3, 2, 3, 2, 3, 2, 10, 2, 3, 2,
    $ 10, 2, 13, 7, 1, 10, 2, 2, 2, 8,
    $ 2, 2, 2, 3, 2, 2, 2, 8, 2, 2, 2,
    $ 2, 32, 2, 2, 2, 8, 2, 2, 2, 3,
    $ 2, 2, 2, 5, 3, 2, 2, 2, 2, 1,
    $ 7/
    DATA num_extreg/ ! number of extra region in a partition!
    $ 16, 16, 16, 16, 16, 16, 16, 16, 16,
    $ 16, 16, 16, 16, 16, 16, 16, 16, 16,
    $ 16, 16, 16, 16, 16, 16, 16, 16, 16,
    $ 16, 16, 16, 16, 16, 16, 16, 16, 16,
    $ 16, 16, 16, 16, 16, 16, 16, 16, 16,
    $ 16, 16, 16, 16, 16, 16, 16, 16, 16,
    $ 16, 16, 16, 16, 16, 16, 16, 16, 16,
    $ 16/
c identification of bending region(if the region is BENDING idbend=1)
    DATA idbend/
    $ 0, 0, 0, 0, 1, 0, 1, 0, 0, 1,
    $ 0, 1, 0, 1, 0, 1, 0, 1, 0, 1,
    $ 0, 0, 0, 0, 0, 0, 1, 0, 1, 0,
    $ 1, 0, 1, 0, 1, 0, 1, 0, 1, 0,
    $ 1, 0, 1, 0, 1, 0, 1, 0, 1, 0,
    $ 1, 0, 1, 0, 0, 1, 0, 1, 0, 0,
    $ 0/
    end

```

B.3.2 tun-geo.f

```

c 0-15m
c 344-348.333m
    subroutine tun_geo_inj( x, y, z,nzt,nzd)
    implicit none
    integer nzt,nzd
    double precision x,y,z
    include 'tun.inc'
    include 'tun_geo.inc'
    mt_t= mt_t_inj ! main tunnel inside dimension
    mt_r= mt_r_inj
    mt_l= mt_l_inj
    mtw_t=mt_t_inj + mtw_t_inj ! main tunnel outdide dimension
    mtw_b=mt_b_inj
    mtw_r=mt_r_inj + mtw_r_inj
    mtw_l=mt_l_inj + mtw_l_inj
    st_t =st_t_inj ! sub tunnel inside dimension
    st_r = st_r_inj
    st_l = st_l_inj
*   stw_t=st_t ! subtunnel outside dimension
    stw_b=st_b + stw_b_inj
    stw_r=st_r + stw_r_inj
    stw_l=st_l + stw_l_inj
    call tun_subgeo(x,y,z,nzt,nzd)
    return
    end

c 10-15m
    subroutine tun_geo_injcol1( x, y, z,nzt,nzd)
    implicit none
    integer nzt,nzd
    double precision x, y, z
    include 'tun.inc'
    include 'tun_geo.inc'
    mt_t= mt_t_col ! main tunnel inside dimension
    mt_r= mt_r_inj
    mt_l= mt_l_col
    mtw_t=mt_t_col + mtw_t_col ! main tunnel outdide dimension
    mtw_b=mt_b + mtw_b_col
    mtw_r=mt_r_inj + mtw_r_injcol
    mtw_l=mt_l_col + mtw_l_col
    st_t =mt_b + st_t_col ! sub tunnel inside dimension
    st_r = st_r_col
    st_l = st_l_col
*   stw_t=st_t ! subtunnel outside dimension
    stw_b=st_b + stw_b_col
    stw_r=st_r + stw_r_col
    stw_l=st_l + stw_l_col
    call tun_subgeo(x,y,z,nzt,nzd)
    return
    end

c 15-17.5m
    subroutine tun_geo_injcol2( x, y, z,nzt,nzd)
    implicit none
    integer nzt,nzd
    double precision x, y, z
    include 'tun.inc'
    include 'tun_geo.inc'
    mt_t= mt_t_col ! main tunnel inside dimension
    mt_r= (mt_r_col+mt_r_inj)/
    % (1750.0-1500.0)*(z-1750.0)+mt_r_col ! HO-beam dump
    mt_l= mt_l_col
    mtw_t=mt_t_col + mtw_t_col ! main tunnel outdide dimension
    mtw_b=mt_b + mtw_b_col
    mtw_r=mt_r_inj + mtw_r_injcol
    mtw_l=mt_l_col + mtw_l_col
    st_t =mt_b + st_t_col ! sub tunnel inside dimension
    st_r = st_r_col
    st_l = st_l_col
*   stw_t=st_t ! subtunnel outside dimension
    stw_b=st_b + stw_b_col
    stw_r=st_r + stw_r_col
    stw_l=st_l + stw_l_col
    call tun_subgeo(x,y,z,nzt,nzd)
    return
    end

c 17.5-32m
c
    subroutine tun_geo_col( x, y, z,nzt,nzd)
    implicit none
    integer nzt,nzd
    double precision x, y, z
    include 'tun.inc'
    include 'tun_geo.inc'
    mt_t= mt_t_col ! main tunnel inside dimension
    mt_r= mt_r_col
    mt_l= mt_l_col
    mtw_t=mt_t_col + mtw_t_col ! main tunnel outdide dimension
    mtw_b=mt_b + mtw_b_col
    mtw_r=mt_r_col + mtw_r_col
    mtw_l=mt_l_col + mtw_l_col
    st_t =mt_b + st_t_col ! sub tunnel inside dimension
    st_r = st_r_col
    st_l = st_l_col
*   stw_t=st_t ! subtunnel outside dimension
    stw_b=st_b + stw_b_col
    stw_r=st_r + stw_r_col
    stw_l=st_l + stw_l_col
    call tun_subgeo( x, y, z,nzt,nzd)
    return
    end

c 32-37.236m
    subroutine tun_geo_colarc1a(x, y, z,nzt,nzd)
    implicit none
    integer nzt,nzd
    double precision x,y,z
    double precision z1,z2,z3,z4,c
    include 'tun.inc'
    include 'tun_geo.inc'
c z values of bending boundary
    z1= 3823.6d0
    z2= 4123.6d0
    z3= 4463.6d0
    z4= 4763.6d0
    mt_t= mt_t_col ! main tunnel inside dimension
    mt_r= mt_r_col
    mt_l= mt_l_col
    mtw_t=mt_t_col + mtw_t_col ! main tunnel outdide dimension
    mtw_b=mt_b + mtw_b_col
    c=mt_r_arc-10.0d0+mtw_r_arc
    c=mt_r_arc+mtw_r_arc
    call antiwallkick2(z,z1,z2,z3,z4,
    & mt_r_col+mtw_r_col,c,mt_r_arc+mtw_r_arc,mtw_r)
    call antiwallkick(z,z1,z2,z3,z4,
    & mt_r_col+mtw_r_col,mt_r_arc+mtw_r_injarc,mtw_r)
    mtw_l=mt_l_col + mtw_l_col
    st_t =mt_b + st_t_col ! sub tunnel inside dimension
    st_r = st_r_col
    st_l = st_l_col
*   stw_t=st_t ! subtunnel outside dimension
    stw_b=st_b + stw_b_col
    stw_r=st_r + stw_r_col
    stw_l=st_l + stw_l_col
    call tun_subgeo(x,y,z,nzt,nzd)
    return
    end

c 37.236-38.236m
    subroutine tun_geo_colarc1a1(x, y, z,nzt,nzd)
    implicit none
    integer nzt,nzd
    double precision x,y,z
    double precision z1,z2,z3,z4,c
    include 'tun.inc'
    include 'tun_geo.inc'
c z values of bending boundary
    z1= 3823.6d0
    z2= 4123.6d0
    z3= 4463.6d0
    z4= 4763.6d0
    mt_t= mt_t_col ! main tunnel inside dimension
    mt_r= mt_r_col
    mt_l= mt_l_col
    mtw_t=mt_t_col + mtw_t_col ! main tunnel outdide dimension
    mtw_b=mt_b + mtw_b_col
    c=mt_r_arc-10.0d0+mtw_r_arc
    c=mt_r_arc+mtw_r_arc
    call antiwallkick2(z,z1,z2,z3,z4,
    & mt_r_col+mtw_r_col,c,mt_r_arc+mtw_r_arc,mtw_r)
    call antiwallkick(z,z1,z2,z3,z4,
    & mt_r_col+mtw_r_col,mt_r.arc+mtw_r_injarc,mtw_r)
    mtw_l=mt_l_col + mtw_l_col
    st_t =mt_b + st_t_col ! sub tunnel inside dimension
    st_r = st_r_col
    st_l = st_l.arc
*   stw_t=st_t ! subtunnel outside dimension
    stw_b=st_b + stw_b_col
    stw_r=st_r + stw_r_col
    stw_l=st_l.col + stw_l_col
    call tun_subgeo(x,y,z,nzt,nzd)
    return
    end

c 38.236-50m
    subroutine tun_geo_colarc1b(x,y,z,nzt,nzd)
    implicit none
    integer nzt,nzd
    double precision x, y, z
    double precision z1,z2,z3,z4,c
    include 'tun.inc'
    include 'tun_geo.inc'
c z values of bending boundary
    z1= 3823.6d0
    z2= 4123.6d0
    z3= 4463.6d0
    z4= 4763.6d0
    mt_t= mt_t.arc ! main tunnel inside dimension
    c=mt_r_col-10.0d0
    c=mt_r.arc
    call antiwallkick2(z,z1,z2,z3,z4,mt_r.col,c,mt_r.arc,mt_r)
    call antiwallkick(z,z1,z2,z3,z4,mt_l.col,mt_l.arc,mt_l)
    mtw_t=mt_t.arc + mtw_t_injarcfirst ! main tunnel outdide dimension
    mtw_b=mt_b + mtw_b_injarc
    call antiwallkick(z,z1,z2,z3,z4,
    & mt_r.col+mtw_r.col,mt_r.arc+mtw_r_injarc,mtw_r)
    c=mt_r.arc-10.0d0+mtw_r.arc
    c=mt_r.arc+mtw_r.arc
    call antiwallkick2(z,z1,z2,z3,z4,
    & mt_r.col+mtw_r.col,c,mt_r.arc+mtw_r.arc,mtw_r)
    call antiwallkick(z,z1,z2,z3,z4,
    & mt_l.col+mtw_l.col,mt_l.arc+mtw_l.injarc,mtw_l)
    st_t =mt_b + st_t.arc ! sub tunnel inside dimension
    st_r = st_r.arc

```

```

st_l = st_l_arc
* stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_arc
stw_r=st_r + stw_r_arc
stw_l=st_l + stw_l_arc
call tun_subgeo( x, y, z,nzt,nzd)
return
end

c
c 50-69.9740m
subroutine tun_geo_colarc1b1(x,y,z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x, y, z
include 'tun.inc'
include 'tun_geo.inc'
mt_t= mt_t_arc ! main tunnel inside dimension
mt_r= mt_r_arc
mt_l= mt_l_arc
mtw_t=mt_t_arc + mtw_t_injarc ! main tunnel outdide dimension
mtw_b=mt_b + mtw_b_injarc
mtw_r=mt_r_arc + mtw_r_injarc
mtw_l=mt_l_arc + mtw_l_injarc
st_t =mt_b + st_t_arc ! sub tunnel inside dimension
st_r = st_r_arc
st_l = st_l_arc
* stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_arc
stw_r=st_r + stw_r_arc
stw_l=st_l + stw_l_arc
call tun_subgeo( x, y, z,nzt,nzd)
return
end

c
c 52-10581.2m arc1
c 157.347-223.873m arc2
c 268.308-324m arc3
subroutine tun_geo_arc( x, y, z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x, y, z
include 'tun.inc'
include 'tun_geo.inc'
mt_t= mt_t_arc ! main tunnel inside dimension
mt_r= mt_r_arc
mt_l= mt_l_arc
mtw_t=mt_t_arc + mtw_t_arc ! main tunnel outdide dimension
mtw_b=mt_b + mtw_b_arc
mtw_r=mt_r_arc + mtw_r_arc
mtw_l=mt_l_arc + mtw_l_arc
st_t =mt_b + st_t_arc ! sub tunnel inside dimension
st_r = st_r_arc
st_l = st_l_arc
* stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_arc
stw_r=st_r + stw_r_arc
stw_l=st_l + stw_l_arc
call tun_subgeo( x, y, z,nzt,nzd)
return
end

c
c 105.812-118.8m
subroutine tun_geo_kick(x,y,z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x,y,z
include 'tun.inc'
include 'tun_geo.inc'
mt_t= mt_t_kick ! main tunnel inside dimension
mt_r= mt_r_kick
mt_l= mt_l_kick
mtw_t=mt_t_kick + mtw_t_kick ! main tunnel outdide dimension
mtw_b=mt_b + mtw_b_kick
mtw_r=mt_r_kick + mtw_r_kick
mtw_l=mt_l_kick + mtw_l_kick
st_t =mt_b + st_t_kick ! sub tunnel inside dimension
st_r = st_r_kick
st_l = st_l_kick
* stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_kick
stw_r=st_r + stw_r_kick
stw_l=st_l + stw_l_kick
call tun_subgeo(x,y,z,nzt,nzd)
return
end

c
c 110-118.8m
subroutine tun_geo_kickexp(x,y,z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x, y, z
include 'tun.inc'
include 'tun_geo.inc'
mt_t= mt_t_exsp ! main tunnel inside dimension
mt_r= mt_r_kick
mt_l= mt_l_exsp
mtw_t=mt_t_exsp + mtw_t_exsp ! main tunnel outdide dimension
mtw_b=mt_b + mtw_b_exsp
mtw_r=mt_r_exsp + mtw_r_exsp
mtw_l=mt_l_exsp + mtw_l_exsp
st_t =mt_b + st_t_exsp ! sub tunnel inside dimension
stw_t=st_t_exsp ! subtunnel outside dimension
stw_b=st_b + stw_b_exsp
stw_r=st_r + stw_r_exsp
stw_l=st_l + stw_l_exsp
call tun_subgeo(x,y,z,nzt,nzd)
return
end

c
c 120.6-134.0m
subroutine tun_geo_exsp(x,y,z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x,y,z
include 'tun.inc'
include 'tun_geo.inc'
mt_t= mt_t_exsp ! main tunnel inside dimension
mt_r= mt_r_exsp
mt_l= mt_l_exsp
mtw_t=mt_t_exsp + mtw_t_exsp ! main tunnel outdide dimension
mtw_b=mt_b + mtw_b_exsp
mtw_r=mt_r_exsp + mtw_r_exsp
mtw_l=mt_l_exsp + mtw_l_exsp
st_t =mt_b + st_t_exsp ! sub tunnel inside dimension
st_r = st_r_exsp
st_l = st_l_exsp
* stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_exsp
stw_r=st_r + stw_r_exsp
stw_l=st_l + stw_l_exsp
call tun_subgeo(x,y,z,nzt,nzd)
return
end

c
c 134.-142m
subroutine tun_geo_exsp_a(x,y,z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x,y,z
include 'tun.inc'
include 'tun_geo.inc'
mt_t= mt_t_exsp ! main tunnel inside dimension
mt_r=(200.d0)/(145.7d2-134.d2)*(z-134.d2)+mt_r_exsp
mt_l= mt_l_exsp
mtw_t=mt_t_exsp + mtw_t_exsp ! main tunnel outdide dimension
mtw_b=mt_b + mtw_b_exsp
mtw_r=mt_r + mtw_r_exsp
mtw_l=mt_l_exsp + mtw_l_exsp
st_t =mt_b + st_t_exsp ! sub tunnel inside dimension
st_r = st_r_exsp
st_l = st_l_exsp
* stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_exsp
stw_r=st_r + stw_r_exsp
stw_l=st_l + stw_l_exsp
call tun_subgeo(x,y,z,nzt,nzd)
return
end

c
c 141-142m
subroutine tun_geo_exsp_a1(x,y,z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x, y, z
include 'tun.inc'
include 'tun_geo.inc'
mt_t= mt_t_exsp ! main tunnel inside dimension
mt_r=(200.d0)/(145.7d2-134.d2)*(z-134.d2)+mt_r_exsp
mt_l= mt_l_exsp
mtw_t=mt_t_exsp + mtw_t_exsp ! main tunnel outdide dimension
mtw_b=mt_b + mtw_b_exsp
mtw_r=mt_r + mtw_r_exsp
mtw_l=mt_l_exsp + mtw_l_exsp
st_t =mt_b + st_t_exsp ! sub tunnel inside dimension
st_r = st_r_exsp
st_l = st_l_arc
* stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_exsp
stw_r=st_r + stw_r_exsp
stw_l=st_l_exsp + stw_l_exsp
call tun_subgeo(x,y,z,nzt,nzd)
return
end

c
c 142-155.847m ! extraction -> arc2 1
subroutine tun_geo_extrarc2_1(x,y,z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x, y, z
double precision z1,z2,z3,z4
include 'tun.inc'
include 'tun_geo.inc'
c z values of bending boundary
Z1= 15434.7d0
Z2= 15734.7d0
Z3= 16074.7d0
Z4= 16374.7d0
mt_t= mt_t_exsp1 ! main tunnel inside dimension
mt_r=(200.d0)/(145.7d2-134.d2)*(z-134.d2)+mt_r_exsp
call antiwallkick(z1,z2,z3,z4,mt_l_exsp,mt_l_arc,mt_l)
mtw_t=mt_t_exsp1 + mtw_t_exsp1 ! main tunnel outdide dimension
mtw_b=mt_b + mtw_b_exsp

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mtw_r=mt_r      + mtw_r_exsp1
call antiwallkick(z,z1,z2,z3,z4,
& mt_l_exsp1 + mtw_l_exsp1, mt_l_arc + mtw_l_arc, mtw_l)
st_t=mt_b      + st_t_exsp1 ! sub tunnel inside dimension
st_r =          st_r_exsp1
st_l =          st_l_arc
*   stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_exsp1
call antiwallkick(z,z1,z2,z3,z4,
& st_r_exsp1+stw_r_exsp1, st_r_arc+stw_r_arc, stw_r)
stw_r=st_r_exsp1 + stw_r_exsp1
stw_l=st_l_arc + stw_l_arc
call tun_subgeo(x,y,z,nzt,nzd)
return
end

c
c 155.847-157.347m arc2 entrance
subroutine tun_geo_arc2_entrance(x,y,z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x, y, z
double precision z1,z2,z3,z4
include 'tun.inc'
include 'tun_geo.inc'
c z values of bending boundary
Z1= 15434.7d0
Z2= 15734.7d0
Z3= 16074.7d0
Z4= 16374.7d0
mt_t= mt_t_exsp1 ! main tunnel inside dimension
mt_r= mt_r_arc
call antiwallkick(z,z1,z2,z3,z4,mt_l_exsp1,mt_l_arc,mt_l)
mtw_t=mt_t_exsp1 + mtw_t_exsp1 ! main tunnel outdide dimension
mtw_b=mt_b      + mtw_b_exsp1
mtw_r=mt_r      + 800.0d0
call antiwallkick(z,z1,z2,z3,z4,
& mt_l_exsp1 + mtw_l_exsp1, mt_l_arc + mtw_l_arc, mtw_l)
st_t =mt_b      + st_t_exsp1 ! sub tunnel inside dimension
st_r =          st_r_arc
st_l =          st_l_arc
*   stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_exsp1
call antiwallkick(z,z1,z2,z3,z4,
& st_r_exsp1+stw_r_exsp1, st_r_arc+stw_r_arc, stw_r)
stw_r=st_r_exsp1 + stw_r_exsp1
stw_l=st_l_arc + stw_l_arc
call tun_subgeo(x,y,z,nzt,nzd)
return
end

c
c 157.347-163.747m
subroutine tun_geo_extrarc2_2(x,y,z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x,y,z
double precision z1,z2,z3,z4
include 'tun.inc'
include 'tun_geo.inc'
c z values of bending boundary
Z1= 15434.7d0
Z2= 15734.7d0
Z3= 16074.7d0
Z4= 16374.7d0
mt_t= mt_t_arc ! main tunnel inside dimension
mt_r= mt_r_arc
call antiwallkick(z,z1,z2,z3,z4,mt_l_exsp1,mt_l_arc,mt_l)
mtw_t=mt_t_arc + mtw_t_arc ! main tunnel outdide dimension
mtw_b=mt_b      + mtw_b_arc
mtw_r=mt_r      + mtw_r_arc
call antiwallkick(z,z1,z2,z3,z4,
& mt_l_exsp1 + mtw_l_exsp1, mt_l_arc + mtw_l_arc, mtw_l)
st_t =mt_b      + st_t_arc ! sub tunnel inside dimension
st_r =          st_r_arc
st_l =          st_l_arc
*   stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_arc
stw_r=st_r + stw_r_arc
stw_l=st_l + stw_l_arc
call tun_subgeo(x,y,z,nzt,nzd)
return
end

c
c 212.523-217.437m
subroutine tun_geo_arc2rf_1( x, y, z, nzt, nzd)
implicit none
integer nzt,nzd
double precision x, y, z
double precision z1,z2,z3,z4
include 'tun.inc'
include 'tun_geo.inc'
c z values of bending boundary
z1= 21252.3d0
z2= 21552.3d0
z3= 21892.3d0
z4= 22192.3d0
mt_t= mt_t_arc ! main tunnel inside dimension
mt_r= mt_r_arc
call antiwallkick(z,z1,z2,z3,z4,mt_l_rf,mt_l)
mtw_t=mt_t_arc + mtw_t_rf ! main tunnel outdide dimension
mtw_b=mt_b      + mtw_b_rf
mtw_r=mt_r_arc + mtw_r_rf
call antiwallkick(z,z1,z2,z3,z4,
& mt_l_rf+mtw_l_rf,mt_l_rf+mtw_l_rf,mtw_l)
st_t =mt_b      + st_t_arc ! sub tunnel inside dimension
stw_b=st_b + stw_b_rf
stw_r=st_r + stw_r_rf
stw_l=st_l + stw_l_rf
call tun_subgeo( x, y, z, nzt, nzd)
return
end

c
c 217.437-221.923m
subroutine tun_geo_arc2rf_2( x, y, z, nzt, nzd)
implicit none
integer nzt,nzd
double precision x, y, z
double precision z1,z2,z3,z4
include 'tun.inc'
include 'tun_geo.inc'
c z values of bending boundary
z1= 21252.3d0
z2= 21552.3d0
z3= 21892.3d0
z4= 22192.3d0
mt_t= mt_t_rf ! main tunnel inside dimension
mt_r= mt_r_rf
call antiwallkick(z,z1,z2,z3,z4,mt_l_rf,mt_l_rf,mt_l)
mtw_t=mt_t_rf + mtw_t_rf ! main tunnel outdide dimension
mtw_b=mt_b      + mtw_b_rf
mtw_r=mt_r_rf + mtw_r_rf
call antiwallkick(z,z1,z2,z3,z4,
& mt_l_rf+mtw_l_rf,mt_l_rf+mtw_l_rf,mtw_l)
st_t =mt_b      + st_t_rf ! subtunnel outside dimension
stw_b=st_b + stw_b_rf
stw_r=st_r + stw_r_rf
stw_l=st_l + stw_l_rf
call tun_subgeo( x, y, z, nzt, nzd)
return
end

c
c 221.923-270.458m
subroutine tun_geo_rf( x, y, z, nzt, nzd)
implicit none
integer nzt,nzd
double precision x, y, z
include 'tun.inc'
include 'tun_geo.inc'
mt_t= mt_t_rf ! main tunnel inside dimension
mt_r= mt_r_rf
mt_l= mt_l_rf
mtw_t=mt_t_rf + mtw_t_rf ! main tunnel outdide dimension
mtw_b=mt_b      + mtw_b_rf
mtw_r=mt_r_rf + mtw_r_rf
mtw_l=mt_l_rf + mtw_l_rf
st_t =mt_b      + st_t_rf ! sub tunnel inside dimension
st_r =          st_r_rf
st_l =          st_l_rf
*   stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_rf
stw_r=st_r + stw_r_rf
stw_l=st_l + stw_l_rf
call tun_subgeo( x, y, z, nzt, nzd)
return
end

c
c 270.458-275.408m
subroutine tun_geo_rfarc3_1( x, y, z, nzt, nzd)
implicit none
integer nzt,nzd
double precision x,y,z
include 'tun.inc'
include 'tun_geo.inc'
c z values of bending boundary
z1= 27045.8d0
z2= 27345.8d0
z3= 27685.8d0
z4= 27985.8d0
mt_t= mt_t_rf ! main tunnel inside dimension
mt_r= mt_r_rf
call antiwallkick(z,z1,z2,z3,z4,mt_l_rf,mt_l_rf,mt_l)
mtw_t=mt_t_rf + mtw_t_rf ! main tunnel outdide dimension
mtw_b=mt_b      + mtw_b_rf
mtw_r=mt_r_rf + mtw_r_rf
call antiwallkick(z,z1,z2,z3,z4,
& mt_l_rf+mtw_l_rf,mt_l_rf+mtw_l_rf,mtw_l)
st_t =mt_b      + st_t_rf ! sub tunnel inside dimension
stw_b=st_b + stw_b_rf
stw_r=st_r + stw_r_rf
stw_l=st_l + stw_l_rf
call tun_subgeo( x, y, z, nzt, nzd)
return
end

c
c 275.408-279.858m
subroutine tun_geo_rfarc3_2( x, y, z, nzt, nzd)
implicit none
integer nzt,nzd
double precision x, y, z
include 'tun.inc'
include 'tun_geo.inc'
c z values of bending boundary

```

```

z1= 27045.8d0
z2= 27345.8d0
z3= 27685.8d0
z4= 27985.8d0
mt_t= mt_t_arc ! main tunnel inside dimension
mt_r= mt_r_arc
call antiwallkick(z,z1,z2,z3,z4,mt_l_rf,mt_l_arc,mt_l)
mtw_t=mt_t_arc + mtw_t_arc ! main tunnel outdiie dimension
mtw_b=mt_b + mtw_b_arc
mtw_r=mt_r_arc + mtw_r_arc
call antiwallkick(z,z1,z2,z3,z4,
$      mt_l_rf+mtw_l_rf,mt_l_arc+mtw_l_arc,mtw_l)
st_t =mt_b + st_t_arc ! sub tunnel inside dimension
stw_t=st_b + stw_b_arc
stw_r=st_r + stw_r_arc
stw_l=st_l + stw_l_arc
call tun_subgeo(x,y,z,nzt,nzd)
return
end

c 275.408-279.858m
subroutine tun_geo_arc3cran_1( x, y,z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x, y, z
double precision z1,z2,z3,z4
include 'tun.inc'
include 'tun_geo.inc'
c z values of bending boundary
z1= 32863.4d0
z2= 33163.4d0
z3= 33503.4d0
z4= 33803.4d0
mt_t= mt_t_arc ! main tunnel inside dimension
call antiwallkick(z,z1,z2,z3,z4,mt_r_arc,mt_r_cran,mt_r)
call antiwallkick(z,z1,z2,z3,z4,mt_l_arc,mt_l_cran,mt_l)
mtw_t=mt_t_arc + mtw_t_arc ! main tunnel outdiie dimension
mtw_b=mt_b + mtw_b_arc
call antiwallkick(z,z1,z2,z3,z4,
$      mt_r_arc + mtw_r_arc, 1.0d4,mtw_r)
$ ! dummy value 0.0d4 much greater than -720.d0
call antiwallkick(z,z1,z2,z3,z4,
$      mt_l_arc+mtw_l_arc,mt_l_cran+mtw_l_cran,mtw_l)
st_t =mt_b + st_t_arc ! sub tunnel inside dimension
st_r = st_r_arc
st_l = st_l_arc
* stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_arc
stw_r=st_r + stw_r_arc
stw_l=st_l + stw_l_arc
call tun_subgeo( x, y, z,nzt,nzd)
return
end

c 328-330m
subroutine tun_geo_arc3cran_2(x,y,z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x, y, z
double precision z1,z2,z3,z4
include 'tun.inc'
include 'tun_geo.inc'
c z values of bending boundary
z1= 32863.4d0
z2= 33163.4d0
z3= 33503.4d0
z4= 33803.4d0
mt_t= mt_t_arc ! main tunnel inside dimension
call antiwallkick(z,z1,z2,z3,z4,mt_r_arc,mt_r_cran,mt_r)
call antiwallkick(z,z1,z2,z3,z4,mt_l_arc,mt_l_cran,mt_l)
mtw_t=mt_t_cran + mtw_t_cran ! main tunnel outdiie dimension
mtw_b=mt_b + mtw_b_arc
call antiwallkick(z,z1,z2,z3,z4,
$      mt_r_arc + mtw_r_arc, 1.0d4,mtw_r)
$ ! dummy value 1.0d4 much greater than -720.d0
call antiwallkick(z,z1,z2,z3,z4,
$      mt_l_arc+mtw_l_arc,mt_l_cran+mtw_l_cran,mtw_l)
st_t =mt_b + st_t_arc ! sub tunnel inside dimension
st_r = st_r_arc
st_l = st_l_arc
* stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_arc
stw_r=st_r + stw_r_arc
stw_l=st_l + stw_l_arc
call tun_subgeo(x,y,z,nzt,nzd)

c
if (y.lt.mtw_l) then
    call antiwallkick(z,z1,z2,z3,z4,mt_l_arc,mt_l_cran,mt_l1)
    call antiwallkick(z,z1,z2,z3,z4,
$      mt_l_arc+mtw_l_arc,mt_l_cran+mtw_l_cran,mtw_l1)
c
endif
return
end

c 330-344m
subroutine tun_geo_cran(x,y,z,nzt,nzd)
implicit none
integer nzt,nzd,kj
double precision x, y, z, ay
double precision z1,z2,z3,z4,zcc
include 'tun.inc'
include 'tun_geo.inc'

data kj/2/
c z values of bending boundary
data z1/32863.4d0/
data z2/33163.4d0/
data z3/33503.4d0/
data z4/33803.4d0/
mt_t= mt_t_cran ! main tunnel inside dimension
mt_r= tan(theta1)*(z-zcran)+mt_r_inj
call antiwallkick(z,z1,z2,z3,z4,mt_l_arc,mt_l_cran,mt_l)
mtw_t=mt_t_cran + mtw_t_cran ! main tunnel outdiie dimension
mtw_b=mt_b + mtw_b_cran
mtw_r= max(mtw_t_inj+mtw_r_inj, mt_r - mtw_r_cran/cos(theta1))
$      mt_l_arc+mtw_l_arc,mt_l_cran + mtw_l_cran,mtw_l)
st_t =mt_b + st_t_cran ! sub tunnel inside dimension
st_r = st_r_cran
st_l = st_l_cran
* stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_cran
stw_r=st_r + stw_r_cran
stw_l=st_l + stw_l_cran
call tun_subgeo(x,y,z,nzt,nzd)
return
end

c 339.984-340.984m
c
subroutine tun_geo_craninj1(x,y,z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x, y, z
double precision z1,z2,z3,z4
include 'tun.inc'
include 'tun_geo.inc'
c z values of bending boundary
data z1/32863.4d0/
data z2/33163.4d0/
data z3/33503.4d0/
data z4/33803.4d0/
mt_t= mt_t_inj ! main tunnel inside dimension
mt_r= max(mtw_t_inj, tan(theta1)*(z-zcran)+mt_r_inj)
mt_l= mt_l_inj
mtw_t=mt_t_cran + mtw_t_cran ! main tunnel outdiie dimension
mtw_b=mt_b + mtw_b_inj
mtw_r= max(mtw_t_inj+mtw_r_inj, mt_r - mtw_r_cran/cos(theta1))
mtw_l=mt_l_inj + mtw_l_inj
st_t =mt_b + st_t_inj ! sub tunnel inside dimension
st_r = st_r_inj
st_l = st_l_inj
* stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_inj
stw_r=st_r + stw_r_inj
stw_l=st_l + stw_l_inj
call tun_subgeo(x,y,z,nzt,nzd)
return
end

c 340.984-348.333m
c
subroutine tun_geo_craninj2(x,y,z,nzt,nzd)
implicit none
integer nzt,nzd
double precision x, y, z
double precision z1,z2,z3,z4
include 'tun.inc'
include 'tun_geo.inc'
c z values of bending boundary
data z1/32863.4d0/
data z2/33163.4d0/
data z3/33503.4d0/
data z4/33803.4d0/
mt_t= mt_t_inj ! main tunnel inside dimension
mt_r= max(mtw_t_inj, tan(theta1)*(z-zcran)+mt_r_inj)
mt_l= mt_l_inj
mtw_t=mt_t_inj + mtw_t_inj ! main tunnel outdiie dimension
mtw_b=mt_b + mtw_b_inj
mtw_r= max(mtw_t_inj+mtw_r_inj, mt_r - mtw_r_cran/cos(theta1))
mtw_l=mt_l_inj + mtw_l_inj
st_t =mt_b + st_t_inj ! sub tunnel inside dimension
st_r = st_r_inj
st_l = st_l_inj
* stw_t=st_t ! subtunnel outside dimension
stw_b=st_b + stw_b_inj
stw_r=st_r + stw_r_inj
stw_l=st_l + stw_l_inj
call tun_subgeo(x,y,z,nzt,nzd)
return
end

subroutine tun_subgeo(x,y,z,nzt,nzd)
implicit none
double precision x, y, z,ax,ay
integer nzt, kj, nzd, i, imax
include 'tun.inc'
ax=ABS(x)
ay=ABS(y)
*****
***                                     TUNNEL DETECTOR
*** ****
*****----- detectors at inner concrete wall -----

```

```

nzd=0
if (ay.le.tun_det_width) then
    if ((x.ge.mt_t).and.(x.le.mt_t+tun_det_thick)) then
        nzd=1      !detector at ceiling wall of main tunnel
        return
    endif
    if ((x.ge.mt_b-tun_det_thick).and.(x.le.mt_b)) then
        nzd=5      !center floor wall of main tunnel
        return
    endif
endif
if ((y.ge.mt_l+tun_det_side-tun_det_width).and.
& (y.le.mt_l+tun_det_side+tun_det_width)) then
    if ((x.ge.mt_t).and.(x.le.mt_t+tun_det_thick)) then
        nzd=2      !detector at (left) ceiling wall of main tunnel
        return
    endif
    if ((x.ge.mt_b-tun_det_thick).and.(x.le.mt_b)) then
        nzd=4      !left floor wall of main tunnel
        return
    endif
    if (nzd.gt.0) return
endif
if (ax.le.tun_det_width) then
    if ((y.ge.mt_l-tun_det_thick).and.(y.le.mt_l)) then
        nzd=3      !detector at left wall of main tunnel
        return
    endif
    if ((y.ge.mt_r).and.(y.le.mt_r+tun_det_thick)) then
        nzd=6      !detector at right wall of main tunnel
        return
    endif
endif
** sub tunnel ---- detector size is same as that of soil-detector
** if (ay.le.soil_det_width) then
    if ((x.ge.st_t).and.(x.le.st_t+soil_det_thick)) then
        nzd=7      !ceiling wall of sub tunnel
        return
    endif
    if ((x.ge.st_b-soil_det_thick).and.(x.le.st_b)) then
        nzd=8      !floor wall of sub tunnel
        return
    endif
endif
----- soil detectors at the tunnel & soil boundary-----
C These detectors are located in concrete side,
C so material is concrete(2001-JUL-31 Nakao)
C
if (ay.le.soil_det_width) then
    if ((x.ge.mtw_t-soil_det_thick).and.(x.le.mtw_t)) then
        nzd=9      !soil contact with tunnel top
        return
    endif
    if ((x.ge.stw_b).and.(x.le.stw_b+soil_det_thick)) then
        nzd=11     !soil contact with sub-tunnel bottom
        return
    endif
endif
if (ax.le.soil_det_width) then
    if ((y.ge.mtw_l).and.(y.le.mtw_l+soil_det_thick)) then
        nzd=10     !soil contact with tunnel left
        return
    endif
    if ((y.ge.mtw_r-soil_det_thick).and.(y.le.mtw_r)) then
        nzd=12     !soil contact with tunnel right
        return
    endif
endif
----- soil detectors at the corner of sub-tunnel side & main-tunnel bottom
C
if ((x.ge.mtw_b-soil_det1_thick).and.(x.le.mtw_b)) then
    if ((y.ge.stw_l-soil_det1_thick).and.(y.le.stw_l)) then
        nzd=13     !soil right side of subtunnel
        return
    endif
    if ((y.ge.stw_r).and.(y.le.stw_r+soil_det1_thick)) then
        nzd=14     !soil left side of subtunnel
        return
    endif
endif
*** LARGE soil detector
if (ay.le.soil_det1_width) then
    if ((x.ge.mtw_t).and.(x.le.mtw_t+soil_det1_thick)) then
        nzd=15     !soil contact with tunnel top
        return
    endif
    if ((x.ge.stw_b-soil_det1_thick).and.(x.le.stw_b)) then
        nzd=17     !soil contact with sub-tunnel bottom
        return
    endif
endif
if (ax.le.soil_det1_width) then
    if ((y.ge.mtw_l-soil_det1_thick).and.(y.le.mtw_l)) then
        nzd=16     !soil contact with tunnel left
        return
    endif
    if ((y.ge.mtw_r).and.(y.le.mtw_r+soil_det1_thick)) then
        nzd=18     !soil contact with tunnel right
        return
    endif
endif
----- detectors at 8,10,11.8m above the beam line-----
do kj=1,n_vert_det
    if ((z.ge.tun_reg(55)).and.(z.le.tun_reg(59)) ! 59,60,61<crane> kj=1,2
    & .and.(kj.le.1)) goto 1111
    if ((z.ge.tun_reg(21)).and.(z.le.tun_reg(25)) ! 25-30<extraction> kj=1
    & .and.(kj.le.1)) goto 1111
    if ((ay.le.vert_det_width(kj)).and.(ay.le.vert_det_height(kj)))
    & .and.(x.le.vert_det_height(kj)+vert_det_thick(kj))) then
        nzd=n_det+kj
        return
    endif
1111 enddo
C----- detector between tunnnel and soil (extreg) -----
c upward
imax=2 ! arc, RF, Kicker, crane
if (((z.ge.tun_reg(0)).and.(z.le.tun_reg(1))).or.
$ ((z.ge.tun_reg(59)).and.(z.le.tun_reg(61)))) imax=4 ! injection
if ((z.ge.tun_reg(1)).and.(z.le.tun_reg(4))) imax=4 ! collimator
if ((z.ge.tun_reg(21)).and.(z.le.tun_reg(25))) imax=5 ! extraction
if ((z.ge.tun_reg(25)).and.(z.le.tun_reg(27))) imax=3 ! extraction
if ((z.ge.tun_reg(54)).and.(z.le.tun_reg(58))) imax=4 ! cran
do i=1,imax
    if ((ay.le.tun_indet_width(i)).and.
        (x.ge.mt_t+tun_indet_dist(i)).and.
        (x.le.mt_t+tun_indet_dist(i)+tun_indet_thick(i))) then
        nzd=num_det+i ! upward concrete inside detector
        return
    endif
enddo
c right
imax=2 ! arc, RF, Kicker, crane
if (((z.ge.tun_reg(0)).and.(z.le.tun_reg(1))).or.
$ ((z.ge.tun_reg(59)).and.(z.le.tun_reg(61)))) imax=3 ! injection
if ((z.ge.tun_reg(1)).and.(z.le.tun_reg(5))) imax=4 ! collimator
if ((z.ge.tun_reg(6)).and.(z.le.tun_reg(6))) imax=3 ! arc1 first
if ((z.ge.tun_reg(21)).and.(z.le.tun_reg(27))) imax=3 ! extraction
do i=iext+1,iext+imax
    if ((ay.le.tun_indet_width(i)).and.
        (y.ge.mt_r+tun_indet_dist(i)).and.
        (y.le.mt_r+tun_indet_dist(i)+tun_indet_thick(i))) then
        nzd=num_det+i ! right concrete inside detector
        return
    endif
33 enddo
c downward
imax=1 ! arc, RF, Kicker, crane
if (((z.ge.tun_reg(0)).and.(z.le.tun_reg(1))).or.
$ ((z.ge.tun_reg(59)).and.(z.le.tun_reg(61)))) imax=3 ! injection
if ((z.ge.tun_reg(1)).and.(z.le.tun_reg(4))) imax=3 ! collimator
if ((z.ge.tun_reg(21)).and.(z.le.tun_reg(25))) imax=3 ! extraction
if ((z.ge.tun_reg(25)).and.(z.le.tun_reg(27))) imax=2 ! extraction
do i=iext+1,iext+imax
    if ((ay.le.tun_indet_width(i)).and.
        (x.ge.mt_b-tun_indet_dist(i)-tun_indet_thick(i)).and.
        (x.le.mt_b-tun_indet_dist(i))) then
        nzd=num_det+i ! downward concrete inside detector
        return
    endif
enddo
c left
imax=2 ! arc, RF, Kicker, crane
if (((z.ge.tun_reg(0)).and.(z.le.tun_reg(1))).or.
$ ((z.ge.tun_reg(59)).and.(z.le.tun_reg(61)))) imax=3 ! injection
if ((z.ge.tun_reg(1)).and.(z.le.tun_reg(7))) imax=4 ! collimator
if ((z.ge.tun_reg(21)).and.(z.le.tun_reg(25))) imax=4 ! extraction
if ((z.ge.tun_reg(25)).and.(z.le.tun_reg(27))) imax=3 ! extraction
do i=iext+1,iext+imax
    if ((ay.le.tun_indet_width(i)).and.
        (y.ge.mt_l-tun_indet_dist(i)-tun_indet_thick(i)).and.
        (y.le.mt_l-tun_indet_dist(i))) then
        nzd=num_det+i ! right concrete inside detector
        return
    endif
34 enddo
c endif
if (nzd.gt.0) return
c **** TUNNEL STRUCTURE ****
*----- air of main tunnel -----
if ((y.ge.mt_l).and.(y.le.mt_r).and.
& (x.ge.mt_b).and.(x.le.mt_t)) then
    nzt=1      !air of main tunnel
    return
endif
*----- air of sub tunnel -----
if ((y.ge.st_l).and.(y.le.st_r).and.
& (x.ge.st_b).and.(x.le.st_t)) then
    nzt=2      !air of sub tunnel
    return
endif
*----- wall of tunnel(concrete) -----
* ceiling wall of main tunnel
* if ((y.ge.mtw_l).and.(y.le.mtw_r).and.
& (x.ge.mt_t).and.(x.le.mtw_t)) then
    nzt=3

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```

    return
  endif
*
* center floor wall of main tunnel
*
  if ((y.ge.stw_l).and.(y.le.stw_r).and.
    & (x.ge.st_t).and.(x.le.mt_b)) then
    nzt=6
    return
  endif
*
* left wall of main tunnel
*
  if ((y.ge.mtw_l).and.(y.le.mt_l).and.
    & (x.ge.mt_b).and.(x.le.mt_t)) then
    nzt=4
    return
  endif
*
* right wall of main tunnel
*
  if ((y.ge.mt_r).and.(y.le.mtw_r).and.
    & (x.ge.mt_b).and.(x.le.mt_t)) then
    nzt=8
    return
  endif
*
* left floor wall of main tunnel
*
  if ((y.ge.mtw_l).and.(y.le.stw_l).and.
    & (x.ge.mtw_b).and.(x.le.mt_b)) then
    nzt=5
    return
  endif
*
* right floor wall of main tunnel
*
  if ((y.ge.stw_r).and.(y.le.mtw_r).and.
    & (x.ge.mtw_b).and.(x.le.mt_b)) then
    nzt=7
    return
  endif
*
* sub tunnel
*
  if ((y.ge.stw_l).and.(y.le.st_l).and.
    & (x.ge.stw_b).and.(x.le.st_t)) then
    nzt=9           !left wall of sub tunnel
    return
  endif
  if ((y.ge.st_r).and.(y.le.stw_r).and.
    & (x.ge.stw_b).and.(x.le.st_t)) then
    nzt=11          !right wall of sub tunnel
    return
  endif
  if ((y.ge.st_l).and.(y.le.st_r).and.
    & (x.ge.stw_b).and.(x.le.st_b)) then
    nzt=10          ! floor of sub tunnel
    return
  endif
  -----
  ----- outer soil -----
  if ((y.ge.outer_soil_l).and.(y.le.outer_soil_r)) then
    if((x.ge.mtw_t).and.(x.le.outer_soil_t)) then
      nzt=nzwall+1           !outer soil top
      return
    endif
    if((x.ge.outer_soil_b).and.(x.le.mtw_b)) then
      nzt=nzwall+2           !outer soil bottom
      return
    endif
    if((x.ge.outer_soil_t).and.(x.le.outer_soil_t+air_thick)) then
      nzt=nzwall+5           !air on the ground
      return
    endif
  endif
  if ((x.ge.mtw_b).and.(x.le.mtw_t)) then
    if ((y.ge.outer_soil_l).and.(y.le.mtw_l)) then
      nzt=nzwall+3           !outer soil left
      return
    endif
    if ((y.ge.mtw_r).and.(y.le.outer_soil_r)) then
      nzt=nzwall+4           !outer soil right
      return
    endif
  endif
  return
end

  subroutine antiwallkick(z,z1,z2,z3,z4,y0,w0,yw)
c
c Anti-wall-kick routine at bending tunnel to describe straight line
c Created by N. Nakao 14-MAY-2001 at Fermilab
c
  implicit none
  double precision z,z1,z2,z3,z4,alpha
  double precision y1,y2,y3,y4,y0,ya,yt
  double precision w1,w2,w3,w4,w0,wa,wt,yw
  data alpha/-130899693899575D+00/
  yt=2.d0*y0*tan(alpha/2.d0)
  y1=y0           + yt*sin(alpha/2.d0)
  y2=y1-(z2-z1)*tan(alpha) + yt*sin(alpha/2.d0+alpha)
  y3=y2-(z3-z2)*tan(alpha*2*)+ yt*sin(alpha/2.d0+alpha*2.d0)
  y4=y3-(z4-z3)*tan(alpha*3*)+ yt*sin(alpha/2.d0+alpha*3.d0)
  if (z.ge.z1) ya=y1-(z-z1)*tan(alpha)
  if ((z.ge.z2).and.(z.le.z3)) ya=y2-(z-z2)*tan(alpha*2.d0)
  if ((z.ge.z3).and.(z.le.z4)) ya=y3-(z-z3)*tan(alpha*3.d0)
  if (z.ge.z4) ya=y4-(z-z4)*tan(alpha*4.d0)
  wt=2.d0*w0*tan(alpha/2.d0)
  w1=w0           + wt*sin(alpha/2.0d0)
  w2=w1-(z4-z3)*tan(alpha) + wt*sin(alpha/2.0d0+alpha)
  w3=w2-(z3-z2)*tan(alpha*2*)+ wt*sin(alpha/2.0d0+alpha*2.d0)
  w4=w3-(z2-z1)*tan(alpha*3*)+ wt*sin(alpha/2.0d0+alpha*3.d0)
  if (z.ge.z4) wa=w0
  if ((z.ge.z3).and.(z.le.z4)) wa=w1-(z4-z)*tan(alpha)
  if ((z.ge.z2).and.(z.le.z3)) wa=w2-(z3-z)*tan(alpha*2.d0)
  if ((z.ge.z1).and.(z.le.z2)) wa=w3-(z2-z)*tan(alpha*3.d0)
  if (z.le.z1) wa=w4-(z1-z)*tan(alpha*4.d0)
  yw=min(wa,ya)
  return
end

  subroutine antiwallkick2(z,z1,z2,z3,z4,y0,v0,w0,yvw)
c
c Anti-wall-kick routine at bending tunnel to describe straight line
c Created by N. Nakao 14-MAY-2001 at Fermilab
c
  implicit none
  double precision z,z1,z2,z3,z4,alpha
  double precision y1,y2,y3,y4,y0,ya,yt
  double precision v1,v2,v3,v4,v0,va,vt
  double precision w1,w2,w3,w4,w0,wa,wt,yvww
  data alpha/-130899693899575D+00/
  yt=2.d0*y0*tan(alpha/2.d0)
  y1=y0           + yt*sin(alpha/2.d0)
  y2=y1-(z2-z1)*tan(alpha) + yt*sin(alpha/2.d0+alpha)
  y3=y2-(z3-z2)*tan(alpha*2*)+ yt*sin(alpha/2.d0+alpha*2.d0)
  y4=y3-(z4-z3)*tan(alpha*3*)+ yt*sin(alpha/2.d0+alpha*3.d0)
  if (z.ge.z1) ya=y0
  if ((z.ge.z2).and.(z.le.z3)) ya=y1-(z-z1)*tan(alpha)
  if ((z.ge.z3).and.(z.le.z4)) ya=y2-(z-z2)*tan(alpha*2.d0)
  if (z.ge.z4) ya=y3-(z-z3)*tan(alpha*3.d0)
  if (z.le.z1) ya=y4-(z-z4)*tan(alpha*4.d0)
  vt=2.d0*v0*tan(alpha/2.d0)
  v1=v0           + vt*sin(alpha/2.d0)
  v2=v1-(z2-z1)*tan(alpha) + vt*sin(alpha/2.d0+alpha)
  v3=v2-(z3-z2)*tan(alpha*2*)+ vt*sin(alpha/2.d0+alpha*2.d0)
  v4=v3-(z4-z3)*tan(alpha*3*)+ vt*sin(alpha/2.d0+alpha*3.d0)
  if (z.ge.z1) va=v0
  if ((z.ge.z2).and.(z.le.z3)) va=v1-(z-z2)*tan(alpha*2.d0)
  if ((z.ge.z3).and.(z.le.z4)) va=v2-(z-z3)*tan(alpha*3.d0)
  if (z.ge.z4) va=v3-(z-z4)*tan(alpha*4.d0)
  if (z.le.z1) va=v4-(z-z1)*tan(alpha*2.d0)
  if (z.ge.z1) va=v0
  if ((z.ge.z2).and.(z.le.z3)) va=v1-(z-z2)*tan(alpha)
  if ((z.ge.z3).and.(z.le.z4)) va=v2-(z-z3)*tan(alpha*2.d0)
  if (z.ge.z4) va=v3-(z-z4)*tan(alpha*3.d0)
  if (z.le.z1) va=v4-(z-z1)*tan(alpha*4.d0)
  yvw=min(va,ya)
  return
end

block data tun_geo_db
  implicit none
  include 'tun_geo.inc'
  data mt_t_inj / 320.d0,
  & mt_r_inj / 400.d0,
  & mt_l_inj / -550.d0,
  & mtw_t_inj / 270.d0,
  & mtw_b_inj / -200.d0,
  & mtw_r_inj / 220.d0,
  & mtw_l_inj / -220.d0,
  & st_t_inj / -220.d0,
  & st_r_inj / 400.d0,
  & st_l_inj / -550.d0,
  & stw_b_inj / -130.d0,
  & stw_r_inj / 100.d0,
  & stw_l_inj / -100.d0
  data mt_t_col / 320.d0,
  & mt_r_col / 250.d0,
  & mt_l_col / -550.d0,
  & mtw_t_col / 350.d0,
  & mtw_b_col / -220.d0,
  & mtw_r_injcol / 280.d0,
  & mtw_r_col / 330.d0,
  & mtw_l_col / -300.d0,
  & st_t_col / -220.d0,
  & st_r_col / 250.d0,
  & st_l_col / -350.d0,
  & stw_b_col / -130.d0,
  & stw_r_col / 100.d0,
  & stw_l_col / -100.d0
  data mt_t_arc / 320.d0,
  & mt_r_arc / 240.d0,
  & mt_l_arc / -460.d0,
  & mtw_t_arc / 100.d0,
  & mtw_b_arc / 100.d0,
  & mtw_r_arc / 100.d0,
  & mtw_l_arc / -100.d0,
  & st_t_arc / -100.d0,
  & st_r_arc / 240.d0,
  & st_l_arc / -160.d0,
  & stw_b_arc / -130.d0,

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&      stw_r_arc/ 100.d0/,
&      stw_l_arc/-100.d0/
data  mtw_t_injarcfirst/ 180.d0/
data  mtw_t_injarc/ 120.d0/,
&      mtw_b_injarc/-100.d0,
&      mtw_r_injarc/ 150.d0/,
&      mtw_l_injarc/-120.d0/
data  mt_t_kick / 320.d0|,
&      mt_r_kick / 250.d0|,
&      mt_l_kick /-470.d0|,
&      mtw_t_kick/ 200.d0|,
&      mtw_b_kick/-100.d0|,
&      mtw_r_kick/ 170.d0|,
&      mtw_l_kick/-150.d0|,
&      st_t_kick /-100.d0|,
&      st_r_kick / 250.d0|,
&      st_l_kick /-150.d0|,
&      stw_b_kick/-130.d0|,
&      stw_r_kick/ 100.d0|,
&      stw_l_kick/-100.d0/
data  mt_t_exsp / 320.d0|,
&      mt_r_exsp / 600.d0|,
&      mt_l_exsp /-470.d0|,
&      mtw_t_exsp/ 450.d0|,
&      mtw_b_exsp/-300.d0|,
&      mtw_r_exsp/ 220.d0|,
&      mtw_l_exsp/-240.d0|,
&      st_t_exsp /-220.d0|,
&      st_r_exsp / 250.d0|,
&      st_l_exsp /-350.d0|,
&      stw_b_exsp/-200.d0|,
&      stw_r_exsp/ 100.d0|,
&      stw_l_exsp/-100.d0/
data  mt_t_exsp1 / 320.d0|,
&      mt_r_exsp1 / 600.d0|,
&      mt_l_exsp1/-470.d0|,
&      mtw_t_exsp1/ 250.d0|,
&      mtw_b_exsp1/-150.d0|,
&      mtw_r_exsp1/ 220.d0|,
&      mtw_l_exsp1/-200.d0|,
&      st_t_exsp1 /-150.d0|,
&      st_r_exsp1 / 250.d0|,
&      st_l_exsp1 /-350.d0|,
&      stw_b_exsp1/-130.d0|,
&      stw_r_exsp1/ 100.d0|,
&      stw_l_exsp1/-100.d0/
data  mt_t_rf / 320.d0|,
&      mt_r_rf / 240.d0|,
&      mt_l_rf /-540.d0|,
&      mtw_t_rf/ 200.d0|,
&      mtw_b_rf/-100.d0|,
&      mtw_r_rf/ 170.d0|,
&      mtw_l_rf/-150.d0|,
&      st_t_rf /-100.d0|,
&      st_r_rf / 240.d0|,
&      st_l_rf /-160.d0|,
&      stw_b_rf/-130.d0|,
&      stw_r_rf/ 100.d0|,
&      stw_l_rf/-100.d0/
data  mt_t_cran / 580.d0|,
&      mt_r_cran / 690.3d0|,
&      mt_l_cran /-550.0d0|,
&      mtw_t_cran/ 270.d0|,
&      mtw_b_cran/-100.d0|,
&      mtw_r_cran/ 150.d0|,
&      mtw_l_cran/-220.d0|,
&      st_t_cran /-100.d0|,
&      st_r_cran / 220.d0|,
&      st_l_cran /-180.d0|,
&      stw_b_cran/-130.d0|,
&      stw_r_cran/ 100.d0|,
&      stw_l_cran/-100.d0/
end

```

B.3.3 tun-local.f

```

c local shield -- extraction
subroutine localshield_geo_ext(x,y,z,nz,za1,za2,za3,za4,nnn)
implicit none
double precision x, y, z
double precision za1,za2,za3,za4,shh,shw
integer nz,nnn
include 'tun.inc'
INTEGER NENTER
DATA NENTER/0/
SAVE NENTER,shh,shw
IF ( NENTER .EQ. 0 ) THEN
    NENTER = 1
    shw=she_w3+she_w2+she_w1
    shh=she_h3+she_h2+she_h1
ENDIF
if ((x.lt.mt_b1).or.(x.gt.she_inh+shh))return
if ((y.lt.-she_inr-shw).or.(y.gt.she_inl+shw)) return
if ((z.ge.za1).and.(z.le.za2)) goto 1
if ((z.ge.za3).and.(z.le.za4)) goto 2
return
*** gate local shield
1   if ((x.gt. she_inh+she_h1+she_h2).or.
     $      (y.lt.-she_inr-she_w1-she_w2).or.
     $      (y.gt. she_inl+she_w1+she_w2)) then
        nz=nnn+1                                ! concrete outer
        return
    endif
    if ((x.gt. she_inh+she_h1).or.
     $      (y.lt.-she_inr-she_w1).or.
     $      (y.gt. she_inl+she_w1)) then
        nz=nnn+2                                ! iron middle
        return
    endif
    if ((x.gt. she_inh).or.
     $      (y.lt.-she_inr).or.
     $      (y.gt. she_inl)) then
        nz=nnn+3                                ! concrete inner
        return
    endif
    nz=nnn+4                                ! air
    return
*** slab local shield
2   if ((x.gt. she_inh+she_h1+she_h2).or.
     $      (y.lt.-she_inr-she_w1-she_w2).or.
     $      (y.gt. she_inl+she_w1+she_w2).or.
     $      (z.lt. za3+she_w3).or.
     $      (z.gt. za4-she_w3)) then
        nz=nnn+5                                ! concrete outer
        return
    endif
    nz=nnn+6                                ! inside iron
    return
end
c local shield -- injection septum
subroutine localshield_geo_injsept(x,y,z,nz,za1,za2,nnn)
implicit none
double precision x, y, z
double precision za1,za2,shh,shw
integer nz,nnn
include 'tun.inc'
double precision s1
data s1/130.d0/
INTEGER NENTER
DATA NENTER/0/
SAVE NENTER,shh,shw
IF ( NENTER .EQ. 0 ) THEN
    NENTER = 1
    shw=sh_w3+sh_w2+sh_w1
    shh=sh_h3+sh_h2+sh_h1
ENDIF
if ((z.lt.za1).or.(z.gt.za2)) return
if ((x.lt.mt_b1).or.(x.gt.sh_inh+shh))return
if ((y.lt.-s1-shw).or.(y.gt.sh_inw+shw)) return
if ((x.lt.sh_inh).and.(y.gt.-s1).and.
     $      (y.lt.sh_inw).and.(z.lt.za2-shw)) return      ! inside air
if ((x.lt.sh_inh+sh_h1).and.(y.gt.-s1-sh_w1).and.
     $      (y.lt.sh_inw+sh_w1).and.(z.lt.za2-shw+sh_w1)) then
    nz=nnn+1                                ! inner concrete
    return
endif
if ((x.lt.sh_inh+sh_h1+sh_h2).and.(y.gt.-s1-sh_w1-sh_w2).and.
     $      (y.lt.sh_inw+sh_w1+sh_w2).and.(z.lt.za2-shw+sh_w1+sh_w2)) then
    nz=nnn+2                                ! inner iron
    return
endif
nz=nnn+3                                ! inner concrete
return
end
c local shield -- collimator region
subroutine localshield_geo_col1(x,y,z,nz,nnn)
implicit none
include 'tun.inc'
double precision x, y, z, ax,ay
double precision cx,cy,cxin,cyin,cy9,cx9,cfe
double precision zcol(n_col_locals),dzcol(n_col_locals)
integer nz,nnn
INTEGER i, ncol
DATA cx/120.d0/
DATA cy/120.d0/

```

```

DATA cxin/40.d0/
DATA cyin/40.d0/
DATA cx9/90.d0/
DATA cy9/90.d0/
DATA zcol/
% 1194.45d0,
% 1424.779d0,
% 1689.4d0,
% 2049.679d0,
% 2302.796d0,
% 2530.837d0,
% 2755.579d0,
% 2997.796d0,
% 3315.5d0/
DATA dzcol/
% 70.d0,
% 70.d0,
% 200.d0,
% 70.d0,
% 70.d0,
% 50.d0,
% 70.d0,
% 80.d0/
DATA cfe/40.d0/
do i=1,n_col_locals
  if ((z.ge.zcol(i)).and.
    & (z.le.zcol(i)+dzcol(i))) then
    nzcol=i*2-1
    ax=abs(x)
    ay=abs(y)
    if (i.eq.9) goto 20
    goto 10
  endif
enddo
return
10 if ((ax.le.cx).and.(ay.le.cy)) then
  if ((ay.ge.cyin).or.(x.ge.cxin)) then
    nz=nnn+nzcol ! concrete
    if ((ay.le.cyin+cfe).and.
      % (x.le.cxin+cfe).and.(x.ge.cxin)) then
      nz=nnn+nzcol+1 ! iron
    endif
  endif
endif
return
20 if ((ax.le.cx9).and.(ay.le.cy9)) then
  nz=nnn+nzcol
endif
return
end

block DATA tun_locals_db
implicit none
include 'tun.inc'
data sh_inh/120.0d0/
data sh_h1/ 25.0d0/
data sh_h2/ 30.0d0/
data sh_h3/ 25.0d0/
data sh_inw/130.0d0/
data sh_w1/ 20.0d0/
data sh_w2/ 40.0d0/
data sh_w3/ 20.0d0/
data mt_b1/-120.0d0/
data sh_window/15.0d0/
data she_inh/ 80.0d0/
data she_h1/ 40.0d0/
data she_h2/ 60.0d0/
data she_h3/ 0.0d0/
data she_inr/ 25.0d0/
data she_inl/160.0d0/
data she_w1/ 40.0d0/
data she_w2/ 40.0d0/
data she_w3/ 40.0d0/
end

```

B.3.4 tun-mat.f

```

subroutine tun_mat_func(nz,im)
implicit none
integer nz,im
include 'tun.inc'
integer tun_mat(tun_nof_zones)
save tun_mat

integer iun,ndat,i,j,k,ii,jj,imax,imax1
integer n_det_div, num_det_div, nia, ia,localdat
parameter(num_det_div=1)
dimension n_det_div(0:num_det_div)
data n_det_div/0,61/
parameter
$ (nia=ibdet*num_det_div*num_det+n_tun_extreg+6+3+2)
dimension ia(nia)
data ia/
1 19,19, ! air in main & sub tunnel
1 9*4, 8, ! concrete(4) & Fe(8)
4 4*24,19, ! soil Tunnel division (ibdet*n_div)
1 6*4, 4,4, 4*4, 6*24, 24,24,24, ! detector z=0-42 (tun_reg: 1~ 8)
e 16*4, ! extra-det(16)
* 4,8,4,19,4,8, ! local shield extraction septum
* 4,8,4, ! local shield injection septum
* 4,8/ ! local shield collimator region
integer NENTER
DATA NENTER/0/
SAVE NENTER
*
** read material data ****
*
IF ( NENTER .EQ. 0 ) THEN
  NENTER = 1
  iun=15
  open(iun,file='TUNNEL_MATERIAL')
  k=0
  ndat=0
*** Tunnel division (ibdet*n_div)
  write(iun,9)
9   format('Tun-div',17x,'nz',7x,'material')
  do j=1,n_tun_div
    do i=1,ibdet
      k=k+1
      tun_mat(k)=ia(ndat+i)
    enddo
    write(iun,10) j,k-ibdet+1,k,(ia(ndat+i),i=1,ibdet)
10  format(15,i18,'-',i5,3x,40i3)
    enddo
    ndat=ndat+ibdet
** detector
    write(iun,12)
12  format('Det-div,Part,Subp,',6x,'nz',7x,'material')
    do j=1, num_det_div
      imax1=0
      do ii=n_det_div(j-1)+1, n_det_div(j)
        imax=num_det + num_extreg(ii)
        do jj=1, num_subp(ii)
          do i=1, imax
            k=k+1
            tun_mat(k)=ia(ndat+i)
          enddo
          write(iun,11) j,ii,jj,k-imax+1,k,(ia(ndat+i),i=1,imax)
11   format(3i5,i8,'-',i5,3x,40i3)
        enddo
        if (imax.gt.imax1) imax1=imax
      enddo
      ndat=ndat+ imax1
      write(*,*) imax1
    enddo
*** local shield for extraction-septum & injection-septum
*** localdat=9
do i=1,localdat
  k=k+1
  ndat=ndat + 1
  tun_mat(k)=ia(ndat)
enddo
write(iun,119) k-2,k,
& (ia(ndat+i),i=1,11)
119 format(15x,i8,'-',i5,3x,10i3)
*** local shield for colmator region
*** ndat=ndat + 1
do i=1,n_col_locals
  k=k+1
  tun_mat(k)=ia(ndat)
  k=k+1
  tun_mat(k)=ia(ndat+1)
enddo
write(iun,219) k-2,k,
& (ia(ndat+i),i=1,11)
219 format(15x,i8,'-',i5,3x,10i3)
*** final check
*** write(*,20) k,tun_nof_zones
write(iun,20) k,tun_nof_zones
20 format(/3x,'tunnel material data : k, tun_nof_zones = ',2i8)
close(iun)
if (k.ne.tun_nof_zones) stop ' NOT equal !!!!'
ENDIF
*****

```

```

im = 0
if ( nz .ge. 1 .and. nz .le. tun_nof_zones ) then
    im = tun_mat(nz)
endif
return
end

subroutine xyout(x,y,z,ioutflag)
implicit none
include 'tun.inc'
include 'tun_geo.inc'
double precision x,y,z,zc1,zc2,mt_t1
integer ioutflag
data zc1,zc2/32863.4d0, 33998.4d0/
* up
IF(z.ge.zc2.and.z.le.zc2+tun_rd_th) THEN !boundary of crane and inj
    mt_t1=mt_t_cran
ELSE
    mt_t1=mt_t
ENDIF
if (x.gt.mt_t1 + tun_rd_th) then
    ioutflag=1
    return
endif
* down
if (((z.ge.34100.d0).and.(z.le.34500.d0)).or.
%   ((z.ge. 1300.d0).and.(z.le. 2700.d0))).and.
%   (y.ge.-sh_inw-sh_w3-sh_w2-sh_w1).and.
%   (y.le. sh_inw+sh_w3+sh_w2+sh_w1)) then
    if (x.lt.mt_b - tun_dp_th1) then
        ioutflag=1
        return
    endif
else
    if (x.lt.mt_b - tun_rd_th) then
        ioutflag=1
        return
    endif
endif
*right
if (y.gt.mt_r + tun_rd_th) then
    ioutflag=1
    return
endif
*left
if (y.lt.mt_l - tun_rd_th) then
    ioutflag=1
    return
endif
return
end

```

B.3.5 xyout.f

subroutine xyout(x,y,z,ioutflag)
 implicit none
 include 'tun.inc'
 include 'tun_geo.inc'
 double precision x,y,z,zc1,zc2,mt_t1
 integer ioutflag
 data zc1,zc2/32863.4d0, 33998.4d0/
* up
 IF(z.ge.zc2.and.z.le.zc2+tun_rd_th) THEN !boundary of crane and inj
 mt_t1=mt_t_cran
 ELSE
 mt_t1=mt_t
 ENDIF
 if (x.gt.mt_t1 + tun_rd_th) then
 ioutflag=1
 return
 endif
* down
 if (((z.ge.34100.d0).and.(z.le.34500.d0)).or.
% ((z.ge. 1300.d0).and.(z.le. 2700.d0))).and.
% (y.ge.-sh_inw-sh_w3-sh_w2-sh_w1).and.
% (y.le. sh_inw+sh_w3+sh_w2+sh_w1)) then
 if (x.lt.mt_b - tun_dp_th1) then
 ioutflag=1
 return
 endif
 else
 if (x.lt.mt_b - tun_rd_th) then
 ioutflag=1
 return
 endif
 endif
*right
 if (y.gt.mt_r + tun_rd_th) then
 ioutflag=1
 return
 endif
*left
 if (y.lt.mt_l - tun_rd_th) then
 ioutflag=1
 return
 endif
 return
end

B.4 Beam Line Modules

B.4.1 Bending magnet

```

! JHP 3 GeV MAGNET by NVM
C   LAST CHANGE: 14-MAR-2001 BY NVM
C   CHANGE: 11-MAY-2001 by Nakao for pipe radius
C   CHANGE: 11-MAY-2001 by Nakao for pipe radius
C   CHANGE: 13-Nov-2001 by Nakao for elliptical pipe

subroutine bend_name_func( type, name )
implicit none
character*80 type
character*80 name
type='SBEND'
name='BM'
return
end

subroutine bend_init_func( type, name, ! type and name
$                           length, pos, ! length and position
$                           f )                      ! field components
implicit none
character*(*) type
character*(*) name
double precision length, pos
double precision f(3)
include 'drift_right.inc'
include 'drift_left.inc'
drift_left_tg_angle = tan( drift_left_angle )
drift_left_sign     = 1.0d0 ! it's for positive bending angles
drift_right_tg_angle = tan(drift_right_angle)
drift_right_sign    = 1.0d0
return
end

subroutine bend_geo_func( length, x, y, z, nz, lf )
c
c Created by N.V.Mokhov as mag_geo_func
c modified by N.Nakao 15-MAY-2001
c modified by N.Nakao 16-JUN-2001 to bend_geo_func
c
implicit none
integer          nz, lf
double precision length, x, y, z
double precision h, v, tmp1, tmp2

include 'bend.inc'
include 'ellipse.inc'
include 'drift_left.inc'
include 'drift_right.inc'
***** JHP BM Beam pipe saggita, 03/09/01 NVM ****=
h1=0.25d0*alpha*length-(alpha/length)*(z-0.5d0*length)**2
h1=y-h1
*****
nz = 0
lf = 0
tmp1 = z + drift_right_sign*drift_right_tg_angle*y
tmp2 = z + drift_left_sign*drift_left_tg_angle*y
if ((tmp2.lt.0.0d0).or.(tmp1.gt.length)) return
v = abs(x)
h = abs(h1)
if ((z.le.0.0d0).or.(z.ge.length)) then
    if ((h.gt.bend_width).or.(v.gt.bend_height)) return
endif
lf = 1
c
r = sqrt(h*h+v*v)

if ((h.le.bend_in_width).and.(v.le.bend_in_height)) nz=1 ! inside air
if (inside_ellipse(v,h,dribmv+dribm_thick,
$                           dribmh+dribm_thick)) nz = 2 ! beam pipe
if (inside_ellipse(v,h,dribmv,dribmh)) nz = 3 ! vacuum inside

if ((h.le.bend_pole_h).and.
& (v.ge.bend_pole_v).and.
& (v.le.bend_in_height)) then
    nz=4 ! pole
    if (x.lt.0.0d0) nz=5 ! pole
***** cited from magnet.f created by N.V.Mokhov*****
* cut in the pole - made it from ellipse
    if (h.gt.mag_ecent_h .and.v.lt.mag_ecent_v)then
        if (.not. inside_ellipse( v-mag_ecent_v,
$           h-mag_ecent_h,
$           mag_eax_v,
$           mag_eax_h)) then
            nz = 1 ! air inside
        endif
    endif
*****
if ((h.le.bend_in_width).and.
& (v.ge.bend_in_height).and.(v.le.bend_height)) then
    nz=6 ! yoke above the pole
    if (x.lt.0.0d0) nz=7 ! yoke below the pole
endif

if ((h.ge.bend_coilpos_h).and.
& (h.le.bend_coilpos_h+bend_coil_h).and.
& (v.ge.bend_coilpos_v).and.
& (v.le.bend_coilpos_v+bend_coil_v)) then
    nz=8 ! coil x>0, y>0
    if (y.lt.0.0d0) nz=9 ! coil x>0, y<0
endif

if (x.lt.0.0d0) nz=nz+2 ! coil x<0, nz=10(y>0) or 11(y<0)
endif

if ((h.ge.bend_in_width).and.
& (h.le.bend_width).and.
& (v.ge.bend_pole_v).and.
& (v.le.bend_height)) then
    nz=12 ! yoke x>0, y>0
    if (y.lt.0.0d0) nz=13 ! yoke x>0, y<0
    if (x.lt.0.0d0) nz=nz+2 ! yoke x<0, nz=14(y>0) or 15(y<0)
endif

if ((h.ge.bend_in_width).and.
& (h.le.bend_width).and.
& (v.ge.bend_pole_v).and.
& (v.le.bend_height)) then
    nz=16 ! yoke y>0
    if (y.lt.0.0d0) nz=17 ! yoke y<0
endif
**** detectors ****
if ((h.le.bend_pole_det_width).and.
& (v.ge.bend_pole_v).and.
& (v.le.bend_pole_v+bend_det_thick)) then
    nz=18 ! pole detector
    if (x.lt.0.0d0) nz=19 ! pole detector
endif
if ((h.le.bend_in_width).and.
& (v.ge.bend_height-bend_det_thick).and.
& (v.le.bend_height)) then
    nz=20 ! detector at the yoke above the pole
    if (x.lt.0.0d0) nz=21 ! detector at the yoke below the pole
endif
if ((h.ge.bend_width-bend_det_thick).and.
& (h.le.bend_width).and.
& (v.ge.bend_pole_v).and.
& (v.le.bend_height)) then
    nz=22 ! detector at yoke x>0, y>0
    if (y.lt.0.0d0) nz=23 ! detector at yoke x>0, y<0
    if (x.lt.0.0d0) nz=nz+2 ! detector at yoke x<0, nz=24(y>0) or 25(y<0)
endif
if (v.le.bend_pole_v) then
    if ((h.ge.bend_in_width).and.
& (h.le.bend_in_width+bend_det_thick)) then
        nz=26 ! inside detector at yoke y>0
        if (y.lt.0.0d0) nz=27 ! inside detector at yoke y<0
    endif
    if ((h.ge.bend_width-bend_det_thick).and.
& (h.le.bend_width)) then
        nz=28 ! outside detector at yoke y>0
        if (y.lt.0.0d0) nz=29 ! outside detector at yoke y<0
    endif
endif
return
end

subroutine bend_mat_func( nz, im )
implicit none
integer nz, im
include 'bend.inc'
integer i
integer bend_mat(bend_nof_zones)
save bend_mat
data bend_mat/
$ 19, 3, 0, 1,1,1,1, 2,2,2, 1,1,1,1,1,1,
* Air,CRM,Void, YOKE , COIL , YOKE,
$ 14,14, 18,18, 17,17,17, 11,11, 16,16/
* YOKE YOKE YOKE YOKE YOKE
im = 0
if ( nz .ge. 1 .and. nz .le. bend_nof_zones ) then
    im = bend_mat(nz)
endif
return
end

subroutine bend_vol_func( nz, length, volume )
implicit none
integer nz
double precision volume, length, ddd
integer i
include 'consts.inc'
include 'bend.inc'
double precision bend_vol(bend_nof_zones)
save bend_vol
data bend_vol/bend_nof_zones*0.0d0/
c beam pipe ceramic
bend_vol(2) =
$ pi*((dribmh+dribm_thick)*(dribmv+dribm_thick)
$ -dribmv*dribmh)*length
bend_vol(8) = bend_coil_h*bend_coil_v*length
bend_vol(9) = bend_vol(8)
bend_vol(10)= bend_vol(8)
bend_vol(11)= bend_vol(8)
c detectors around the yoke
ddd=bend_det_thick*length
bend_vol(18) = bend_pole_h*2.0d0 * ddd
bend_vol(19) = bend_vol(18)
bend_vol(20) = bend_in_width*2.0d0 * ddd
bend_vol(21) = bend_vol(22)
bend_vol(22) = (bend_height-bend_pole_v) * ddd
bend_vol(23) = bend_vol(22)
bend_vol(24) = bend_vol(22)
bend_vol(25) = bend_vol(22)
bend_vol(26) = bend_pole_v * 2.0d0 * ddd
bend_vol(27) = bend_vol(26)

```

```

bend_vol(28) = bend_vol(26)
bend_vol(29) = bend_vol(26)
volume = 0.0d0
if ( nz .ge. 1 .and. nz .le. bend_nof_zones ) then
    volume = bend_vol(nz)
endif
return
end

subroutine bend_field_func( length,
$                                f,
$                                x, y, z,
$                                bx, by, bz, bbb )

```

C LAST CHANGE: 13-MAR-2001 BY NVM
C LAST CHANGE: 16-JUN-2001 BY N.NAKAO
implicit none
double precision length, x, y, z
double precision bx, by, bz, bbb
double precision f(3)
double precision h, v, r ,tmp1, tmp2
include 'bend.inc'
include 'drift_left.inc'
include 'drift_right.inc'
**** JHP BM Beam pipe saggita, 03/09/01 NVM ======
hi=0.25d0*alpha*length-(alpha/length)*(z-0.5d0*length)**2
hi=y-h1

bx = 0.0d0
by = 0.0d0
bz = 0.0d0
bbb = 0.0d0

tmp1 = z + drift_right_sign*drift_right_tg_angle*y
tmp2 = z + drift_left_sign*drift_left_tg_angle*y
if ((tmp2.lt.0.0d0).or.(tmp1.gt.length)) return
c if (z.gt.0.0d0) then
c if (z.lt.length) then
h = abs(h1)
v = abs(x)
if (h .lt. bend_width) then
 if (v .lt. bend_height) then
 call dipole_field(x,h1,f(1),bx,by)
 bbb = sqrt(bx**2 + by**2)
 endif
endif
c endif
c endif
c endif
return
end

subroutine dipole_field(x,y,bdip,bx,by)
IMPLICIT DOUBLE PRECISION (A-H,O-Z), INTEGER (I-N)
c.....
C JHP 3 GeV DIPOLE FIELD
C----
C CREATED: 13-MAR-2001 BY N.MOKHOV
C LAST CHANGE: 13-MAR-2001 BY NVM
C----
C.....
C BM B=-1.1 T at 3 GeV and B=-0.2744 T at 400 MeV
COMMON
& /BMMAP/BXB(150,150),BYB(150,150),XBM(150),YBM(150),DLXB,DLYB
& /QMMAP/BXQ(180,180),BYQ(180,180),XQM(180),YQM(180),DLXQ,DLYQ
& /FMPSSIZ/NXB,NYB,NXQ,NYQ
C MAP NOMINAL FIELDS:
PARAMETER (BBD =1.1D0)
C-----
LL=1
SCF = BDIP/BBD !!!!!!
XMAP=ABS(X)
YMAP=ABS(Y)
BX=0.DO
BY=0.DO
IX=INT(XMAP/DLXB)+1
IY=INT(YMAP/DLYB)+1
CALL LITWOD(XMAP,YMAP,LL,1,FOUT)
BX=FOUT*SCF
CALL LITWOD(XMAP,YMAP,LL,2,FOUT)
BY=FOUT*SCF
B=SQRT(BX**2+BY**2)
IF(B.LT.1.0D-07) GO TO 1
IF(X.LT.0.0D0) BY=-BY
IF(Y.LT.0.0D0) BY=-BY
1 RETURN
END

block data bend_db
implicit none
include 'bend.inc'
data bend_width/76.5d0/
data bend_height/62.0d0/
data bend_in_width/45.0d0/
data bend_in_height/34.0d0/
data bend_pole_v/10.5d0/
data bend_pole_h/25.0d0/
data bend_coil_h/18.0d0/
data bend_coil_v/21.0d0/
data bend_coilpos_h/26.0d0/
data bend_coilpos_v/12.0d0/
data bend_det_thick/3.0d0/
data bend_pole_det_width/15.0d0/
data mag_ecent_h/17.0d0/

data mag_ecent_v/18.5d0/ !!! mag_v_gap+mag_v_coil
data mag_eax_h/8.0d0/ !!!
data mag_eax_v/8.0d0/ !!! == coil_v
data dribmh/12.0d0/
data dribmv/9.35d0/
data dribm_thick/0.5d0/
**** JHP BM Beam pipe saggita, 03/09/01 NVM ======
*** alpha=0.26179939d0+0.5d0 ! temporary, fixed 05/15/01 by NVM
data alpha/0.130899693899575D+00/
end

B.4.2 Quadrupole magnet

```

! JJK Quadrupole magnet
!
! QUAD Bohr radius 330mm
! QUAD Bohr radius 270mm
!
C Last CHANGE: 15-MAY-2001 by Nakao for pipe radius
C Last CHANGE: 24-MAY-2001 by Nakao for quad for JJK
C Last CHANGE: 13-NOV-2001 by Nakao for quad for JJK 3GeV 10/9

subroutine quadru_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'QUADRUPOLE'
name = 'QUAD'
return
end

subroutine quadru19_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'QUADRUPOLE'
name = 'QUAD19'
return
end

subroutine quadru_init_func( type, name, ! type and name
$                               length, pos, ! length and position
$                               f )                      ! field components
implicit none
character*(*) type
character*(*) name
double precision length, pos
double precision f(3)
return
end

subroutine quadru_geo_func(length,x,y,z,nz,lf)
implicit none
integer          nz, lf
double precision length, x, y, z
include 'quadru.inc'
nz = 0
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
qf1=4.8d0
qf2=20.0d0
qg1=4.8d0
qg2=18.0d0
qh1=5.6953d0
qh2=16.0d0
qj =9.54594d0
afxp=13.5
r_pipe=13.5d0 ! inner radius of beam pipe[cm]
call quadru_subgeo(x,y,z,nz)
return
end

subroutine quadru19_geo_func(length,x,y,z,nz,lf)
implicit none
integer          nz, lf
double precision length, x, y, z
include 'quadru.inc'
nz = 0
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
qf1=6.0d0
qf2=23.0d0
qg1=6.0d0
qg2=21.0d0
qh1=7.11645d0
qh2=19.0d0
qj =11.6673d0
afxp=16.5
r_pipe=19.0d0 ! inner radius of beam pipe[cm]
call quadru_subgeo(x,y,z,nz)
return
end

subroutine quadru_subgeo(x,y,z,nz)
implicit none
integer nz,lf,ia,iflag
DOUBLE PRECISION x,y,z,r,h,v,r1,pve,pve1
DOUBLE PRECISION hh,h1,h2,h4,h5,h6,h7,h8,h9,ah1,ah2
include 'quadru.inc'
v=ABS(x)
h=ABS(y)
ia=0
if (x.le.0.0d0) ia=ia+2
if (y.le.0.0d0) then
  ia=ia+1
  if (v.le.h) ia=ia+1
else
  if (v.ge.h) ia=ia+1
endif
ia=ia*n_sym ! number of symmetric material
iflag=0
if (v.lt.h) then
  iflag=1
  tmp=v
  v=h
  h=tmp
endif
if ((v.le.qa).and.(v.le. -h+qa+qi)) then
  nz=1+ia           ! yoke1
  hh=(qc-qd1)/(qb-qd2)*(v-qa+qi)+qd1
  if ((v.le.qb).and.(h.le.hh)) then
    nz=2+ia           ! air
c pole
  if ((v.ge.qe2).and.(v.le.qd2)) then
    h1=(qe1-qd1)/(qe2-qd2)*(v-qa+qi)+qe1
    if (h.ge.h1) nz=3+ia !pole
  endif
  if ((v.ge.qf2).and.(v.le.qe2)) then
    h2=(qe1-qf1)/(qe2-qf2)*(v-qa+qi)+qe1
    if (h.ge.h2) nz=3+ia !pole
  endif
  if ((v.ge.qg2).and.(v.le.qf2).and.(h.ge.qf1)) nz=3+ia !pole
  if ((v.ge.qh2).and.(v.le.qg2)) then
    h4=(qg1-qh1)/(qg2-qh2)*(v-qa+qi)+qh1
    if (h.ge.h4) nz=3+ia !pole
  endif
  if ((v.le.qh2).and.(v.ge.qj)) then
    h5=afxp**2/2.0d0/v
    if (h.ge.h5) nz=3+ia !pole
  endif
c pole volume estimate region
  pve=(afxp+ra)/1.41421356d0
  r1=sqrt((v-pve)**2+(h-pve)**2)
  pve1=-h**2.0d0*pve
  if ((r.lt.ra).and.(v.le.pve1)) nz=8+ia
c coil
  ah1=(qe1-qd1)/(qe2-qd2)
  ah2=(qc-qd1)/(qb-qd2)
  h6=ah1*(v-coil_b2)+coil_b1
  h7=ah2*(v-coil_a2)+coil_a1
  h8=ah1*(v-coil_a2)+coil_a1
  h9=ah2*(v-coil_b2)+coil_b1
  if ((h.ge.h6).and.(h.ge.h7).and.
       (h.le.h8).and.(h.le.h9)) then
    if (iflag.eq.1) then
      nz=4+ia           !coil
    else
      nz=5+ia           !coil
    endif
  endif
  if ((v.ge.qa-qdet_thick).and.(v.le.qa).and.
       (h.le.qi)) then
    if (iflag.eq.1) then
      nz=6+ia           !detector
    else
      nz=7+ia           !detector
    endif
  endif
  r=sqrt(x*x+y*y)
  if (r.le.r_pipe+t_pipe) then
    nz=33               ! beam pipe
    if (r.le.r_pipe) nz=34 ! beam duct void
  endif
  return
end

subroutine quadru_mat_func(nz,im)
implicit none
integer nz, im
include 'quadru.inc'
integer quadru_mat(quadru_nof_zones)
  YOKE,AIR,YOKE,COIL,COIL,YOKE,YOKE, CRMC,VOID
data quadru_mat/
$   1, 19,   1,   2,   2, 18,18,14,
$   1, 19,   1,   2,   2, 18,18,14,
$   1, 19,   1,   2,   2, 18,18,14,
$   1, 19,   1,   2,   2, 18,18,14,
im = 0
if ( nz .ge. 1 .and. nz .le. quadru_nof_zones ) then
  im = quadru_mat(nz)
endif
return
end

subroutine quadru_field_func( length,
$                               f,
$                               x, y, z,
$                               bx, by, bz, bbb )
implicit none
double precision length, x, y, z
double precision bx, by, bz, bbb
double precision f(3)
double precision h, v
integer LL
include 'quadru.inc'
bx = 0.0d0
by = 0.0d0
bz = 0.0d0
bbb = 0.0d0
LL=2
if ((z.gt.0.0d0).and.(z.lt.length)) then
  h = abs(y)
  v = abs(x)
  if ((h.lt.qa).and.(v.lt.qa)) then
    call quad_field(x,y,f(2),bx,by,LL)
    bbb = sqrt( bx*bx + by*by )
  endif
endif

```

```

endif
return
end

subroutine quadru19_field_func( length,
$                                f,
$                                x, y, z,
$                                bx, by, bz, bbb )
implicit none
double precision length, x, y, z
double precision bx, by, bz, bbb
double precision f(3)
double precision h, v
integer LL
include 'quadru.inc'
bx = 0.0d0
by = 0.0d0
bz = 0.0d0
bbb = 0.0d0
LL=3
if ((z.gt.0.0d0).and.(z.lt.length)) then
  h = abs(y)
  v = abs(x)
  if ((h.lt.qa).and.(v.lt.qa)) then
    call quad_field(x,y,f(2),bx,by,LL)
    bbb = sqrt( bx*bx + by*by )
  endif
endif
return
end

subroutine quad_field(x,y,b0,bx,by,LL)
IMPLICIT DOUBLE PRECISION (A-H,O-Z), INTEGER (I-N)
c................................................................
C JHP 3 GeV QUAD FIELD
C-----
C CREATED: 13-MAR-2001 BY N.MOKHOV
C LAST CHANGE: 13-MAR-2001 BY NVM
C LAST CHANGE: 24-MAY-2001 BY Nakao
C LAST CHANGE: 6-JUN-2001 BY Nakao
C LAST CHANGE: 7-JUN-2001 BY Nakao
C-----
C.....LL=2
C QMF Bohr=270mm G=-4.5 T/M at 3 GeV and G=-1.1227 T/m at 400 MeV
C QMD Bohr=270mm G+=4.5 T/M at 3 GeV and G+=1.1227 T/m at 400 MeV
C LL=3
C LQMF Bohr=330mm G=-3.83 T/M at 3 GeV and G=- T/m at 400 MeV
C LQMD Bohr=330mm G+=3.83 T/M at 3 GeV and G+= T/m at 400 MeV
COMMON
& /BMMAP/BXB(150,150),BYB(150,150),XBM(150),YBM(150),DLXB,DLYB
& /QMMAP/BXQ(180,180),BYQ(180,180),XQM(180),YQM(180),DLXQ,DLYQ
& /LMMAP/BXL(180,180),BYL(180,180),XLM(180),YLM(180),DLXL,DLYL
& /FMPORIZ/NXB,NYB,NXQ,NYQ,NXL,NYL
C MAP NOMINAL FIELDS:
c PARAMETER (GLB =0.045D0)
dimension GLB(3) ! nakao
data GLB/0.0d0, 0.045D0, 0.0383D0/ ! nakao GLB= dB/dL[T/cm]
c-----c
c SCF = BO/GLB !!!!!!!
c SCF = BO/GLB(LL)/alength*100.0d0 !!!!!!! alength[m] ! nakao
SCF = BO/GLB(LL) ! nakao
XMAP=ABS(X)
YMAP=ABS(Y)
BX=0.DO
BY=0.DO
iflag=0 ! nakao
*****IF(XMAP.LE.YMAP) THEN
  IX=INT(XMAP/DLXQ)+1
  IY=INT(YMAP/DLYQ)+1
ELSE
  XMAP=YMAP
  YMAP=ABS(X)
  IX=INT(XMAP/DLYQ)+1
  IY=INT(YMAP/DLXQ)+1
iflag=1 ! nakao
END IF
*****CALL LITWOD(XMAP,YMAP,LL,1,FOUTx)
BX=FOUTx*SCF ! nakao
CALL LITWOD(XMAP,YMAP,LL,2,FOUTy) ! nakao
BY=FOUTy*SCF ! nakao
B=SQRT(BX**2+BY**2)
c write(99,99) LL,B0,GLB(LL),SCF,y,FOUTy,BY,x,FOUTx,B,alength ! nakao
c 99 format(i2,0p11f10.5)
IF(B.LT.1.0D-07) GO TO 1
if (iflag.eq.1) then ! nakao
  tmp=BY ! nakao
  BY=BX ! nakao
  BX=tmp ! nakao
endif
IF(X.LT.0.ODO) BY=-BY
IF(Y.LT.0.ODO) BX=-BX
1 RETURN
END

subroutine quadru_vol_func(nz,length,volume)
implicit none
integer nz
double precision length, volume
include 'quadru.inc'
r_pipe=13.5
call quadru_subvol(nz,length,volume)
return

```

```

end

subroutine quadru19_vol_func(nz,length,volume)
implicit none
integer nz
double precision length, volume
include 'quadru.inc'
r_pipe=19.0
call quadru_subvol(nz,length,volume)
return
end

subroutine quadru_subvol(nz,length,volume)
implicit none
integer nz,i
double precision length, volume
include 'quadru.inc'
include 'consts.inc'
double precision quadru_vol(quadru_nof_zones)
save quadru_vol
data quadru_vol/quadru_nof_zones*0.0d0/
double precision aa,bb
data aa/16.042d0/
data bb/8.021d0/
do i=0,3
*** coil ***
  quadru_vol(4+i*n_sym)=aa*bb*length
  quadru_vol(5+i*n_sym)=aa*bb*length
*** detector YOKE outside***
  quadru_vol(6+i*n_sym)=qi*qdet_thick*length
  quadru_vol(7+i*n_sym)=qi*qdet_thick*length
*** detector (sphere in the poles) ***
  quadru_vol(8+i*n_sym)=0.5d0*pi*ra*ra*length
enddo
*** beam pipe (ceramic) ***
  quadru_vol(33)=pi*((r_pipe+t_pipe)**2-r_pipe**2)*length
volume = 0.0d0
if ( nz .ge. 1 .and. nz .le. quadru_nof_zones ) then
  volume = quadru_vol(nz)
endif
write(65,109) nz,volume,length,volume/length
109 format(12x,'quadrupole ',i3,
  &           ' volume,length,volume/length= ',1p3e10.3/)
return
end

block data quadru_db
include 'quadru.inc'
data qa /64.0d0/,
$ qb /48.0d0/,
$ qc /11.0d0/,
$ qd1/19.0d0/,
$ qd2/42.0d0/,
$ qe1/9.0d0/,
$ qe2/28.0d0/,
$ qi /26.5096d0/,
& coil_a1 /8.67577d0/,
& coil_a2 /28.946d0/,
& coil_b1 /11.5832d0/,
& coil_b2 /46.8126d0/,
& qdet_thick /3.0d0/,
$ t_pipe/1.0d0, ! thickness of beam pipe[cm]
$ ra/5.0d0/ ! radius of sphere in the pole detector
end

```

B.4.3 Drift spece(beam pipe)

```

!
! DRIFT
!
C   Last CHANGE: 15-MAY-2001 by Nakao  for pipe radius
C   Last CHANGE: 12-NOV-2001 by Nakao  for pipe radius

subroutine drift_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'DRIFT'
return
end

subroutine driftx_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'DRIFTX'
return
end

subroutine drift_init_func( type, name, ! type and name
$                           length, pos, ! length and position
$                           f )           ! field components
implicit none
character(*) type
character(*) name
double precision length
double precision pos
double precision f(3)
return
end

subroutine drift_geo_func(length,x,y,z,nz,lf)
implicit none
integer nz,lf
double precision length, x,y,z,r
include 'drift.inc'
nz = 0
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
r=sqrt(x*x+y*y)
if (r.le.drift_in+drift_thick) then ! that's beam pipe
  nz = 1
  if (r.le.drift_in) nz = 2 ! that's vacuum inside
endif
return
end

subroutine driftx_geo_func(length,x,y,z,nz,lf)
implicit none
integer nz,lf
double precision length, x,y,z,r
include 'drift.inc'
nz = 0
lf = 0
if ((z.lt.-1100.0d0).or.(z.gt.length)) return
if (y.lt.450.d0) return
lf = 1
return
end

subroutine drift_mat_func( nz, im )
implicit none
integer nz, im
include 'drift.inc'
integer drift_mat(drift_no_f_zones)
save   drift_mat
data drift_mat/22, 0/ ! STST,void
im = 0
if ( nz .ge. 1 .and. nz .le. drift_no_f_zones ) then
  im = drift_mat(nz)
endif
return
end

subroutine drift_field_func(length,f,x,y,z,bx,by,bz,bbb)
implicit none
double precision length, x, y, z, bx, by, bz, bbb
double precision f(3)
bx = 0.0d0
by = 0.0d0
bz = 0.0d0
bbb = 0.0d0
return
end

subroutine drift_vol_func(nz,length,volume)
implicit none
include 'consts.inc'
include 'drift.inc'
integer nz
double precision length, volume
double precision drift_vol(drift_no_f_zones)
save   drift_vol
data drift_vol/drift_no_f_zones*0.0d0/
drift_vol(2)=length * pi* drift_in**2 ! vacuum
drift_vol(1)=
& length*pi*(drift_in+drift_thick)**2-drift_vol(2) ! beam pipe shell

```

B.4.4 Septum

```

!
! Septum a & b for extraction
!
subroutine septum_a_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'SEPTUMA'
return
end

subroutine septum_b_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'SEPTUMB'
return
end

subroutine septum_c_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'SEPTUMC'
return
end

subroutine septum_d_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'SEPTUMD'
return
end

subroutine septum_inj_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'SEPTUMINJ'
return
end

subroutine septum_init_func( type, name, ! type and name
$                               length, pos, ! length and position
$                               f )                  ! field components
implicit none
character(*) type
character(*) name
double precision length, pos
double precision f(3)
return
end

subroutine septum_a_geo_func(length,x,y,z,nz,lf)
implicit none
integer          nz, lf
double precision length, x, y, z
include 'septum.inc'
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
call septum_a_geo1
call septum_subgeo(x,y,nz)
return
end

subroutine septum_b_geo_func(length,x,y,z,nz,lf)
implicit none
integer          nz, lf
double precision length, x, y, z
include 'septum.inc'
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
call septum_b_geo1
call septum_subgeo(x,y,nz)
return
end

subroutine septum_c_geo_func(length,x,y,z,nz,lf)
implicit none
integer          nz, lf
double precision length, x, y, z
include 'septum.inc'
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
call septum_c_geo1
call septum_subgeo(x,y,nz)
return
end

subroutine septum_d_geo_func(length,x,y,z,nz,lf)
implicit none
integer          nz, lf
double precision length, x, y, z
include 'septum.inc'
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
call septum_d_geo1
call septum_subgeo(x,y,nz)
return
end

subroutine septum_d_geo1( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'SEPTUMD'
return
end

subroutine septum_inj_geo_func(length,x,y,z,nz,lf)
implicit none
integer          nz, lf
double precision length, x, y, z
include 'septum.inc'
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
call septum_inj_geo1
call septum_subgeo(x,y,nz)
return
end

subroutine septum_subgeo(x,y,nz)
implicit none
integer nz
double precision x,y,ax,ay,r,aaa
include 'septum.inc'
nz = 0
ax=ABS(x)
ay=ABS(y)
r=SQRT(x*x+y*y)
C-----vacuum duct-----
IF (LD.eq.1) then           ! rectangular duct
    if ( ay .le. se_duct_ow .and. ax .le. se_duct_oh ) then
        nz = 2                 !vacuum duct
        if (ay.le.se_duct_iw.and.ax.le.se_duct_ih) nz = 1 !vacuum
    c      return
    endif
else                         ! cylidrical duct
    if ( r .le. se_duct_thick) then
        nz = 2                 !vacuum duct
        if ( r .le. se_duct_r) nz = 1 !vacuum
    c      return
    endif
ENDIF
C-----EM shield-----
if ((y.ge.se_deck_w).and.(y.le.se_core_iw).and.
&   ( ax .le. se_deck_h)) then
    nz = 3                 !EM shield
    return
endif
C-----inner core-----
if (ax.le.se_coil_h) then
    if ((y.ge.se_vac_w).and.(y.le.se_coil_ow)) then
        nz = 4                 !outside coil
        return
    endif
    if ((y.ge.se_coil_iw).and.(y.le.se_vac_w)) then
        nz = 5                 !extraction line
        return
    endif
    if ((y.ge.se_core_iw).and.(y.le.se_coil_iw)) then
        nz = 6                 !inside coil
        return
    endif
endif
C-----septum core-----
if ((y.ge.se_core_iw).and.(y.le.se_coil_ow)) then
    if (ax.le.se_deck_h) then
        nz = 7                 !YOKE above and below coil
        return
    endif
    if (ax.le.se_core_h) then
        nz = 8                 !YOKE above and below coil
        return
    endif
    if ((ax.le.se_core_h).and.
&     (y.ge.se_coil_ow).and.(y.le.se_core_ow)) then
        nz=9 ! core inside
        aaa=se_coil_ow+0.5d0*(se_core_ow-se_coil_ow)
        if (y.ge.aaa) nz=10 ! core outside
        return
    endif
endif
subroutine septum_mat_func( nz, im )
implicit none
integer nz, im
include 'septum.inc'
integer septum_mat(septum_nof_zones)
data septum_mat
&/, 22, 8, 2, 0, 2, 14,11,16,18/ !ext_septum A
c void,STST,FE,COIL,void,COIL,YOKE
im = 0
if ( nz .ge. 1 .and. nz .le. septum_noф_zones ) then
    im = septum_mat(nz)
endif
return
end

subroutine septum_field_func(length,f,x,y,z,bx,by,bz,bbb)
implicit none
double precision length, x, y, z
double precision bx, by, bz, bbb

```

```

double precision f(3)
double precision h, v, rq, r4, tmp
include 'septum.inc'
bx = 0.0d0
by = 0.0d0
bz = 0.0d0
bbb = 0.0d0
return
end

subroutine septum_a_vol_func(nz,length,volume)
implicit none
integer nz
double precision length, volume
include 'septum.inc'
double precision septum_a_vol(septum_no_f_zones)
save septum_a_vol
data septum_a_vol/septum_no_f_zones*0.0d0/
integer NENTER, i
DATA NENTER/0/
SAVE NENTER
IF (NENTER.EQ.0) THEN
  NENTER = 1
  call septum_a_geo1
  call septum_subvol
  do i=1,septum_no_f_zones
    septum_a_vol(i)=vv(i) !! must multiply (length) later
  enddo
ENDIF
volume = 0.0d0
if ( nz .ge. 1 .and. nz .le. septum_no_f_zones ) then
  volume = septum_a_vol(nz) *length ! now multiplying (length)
endif
write(65,109) nz,volume,length,volume/length
109 format(12x,'septum_a ',i3,
  & ' volume,length,volume/length= ',1p3e10.3/)
return
end

subroutine septum_b_vol_func(nz,length,volume)
implicit none
integer nz
double precision length, volume
include 'septum.inc'
double precision septum_b_vol(septum_no_f_zones)
save septum_b_vol
data septum_b_vol/septum_no_f_zones*0.0d0/
integer NENTER, i
DATA NENTER/0/
SAVE NENTER
IF (NENTER.EQ.0) THEN
  NENTER = 1
  call septum_b_geo1
  call septum_subvol
  do i=1,septum_no_f_zones
    septum_b_vol(i)=vv(i) !! must multiply (length) later
  enddo
ENDIF
volume = 0.0d0
if ( nz .ge. 1 .and. nz .le. septum_no_f_zones ) then
  volume = septum_b_vol(nz) *length ! now multiplying (length)
endif
write(65,109) nz,volume,length,volume/length
109 format(12x,'septum_b ',i3,
  & ' volume,length,volume/length= ',1p3e10.3/)
return
end

subroutine septum_c_vol_func(nz,length,volume)
implicit none
integer nz
double precision length, volume
include 'septum.inc'
double precision septum_c_vol(septum_no_f_zones)
save septum_c_vol
data septum_c_vol/septum_no_f_zones*0.0d0/
integer NENTER, i
DATA NENTER/0/
SAVE NENTER
IF (NENTER.EQ.0) THEN
  NENTER = 1
  call septum_c_geo1
  call septum_subvol
  do i=1,septum_no_f_zones
    septum_c_vol(i)=vv(i) !! must multiply (length) later
  enddo
ENDIF
volume = 0.0d0
if ( nz .ge. 1 .and. nz .le. septum_no_f_zones ) then
  volume = septum_c_vol(nz) *length ! now multiplying (length)
endif
write(65,109) nz,volume,length,volume/length
109 format(12x,'septum_c ',i3,
  & ' volume,length,volume/length= ',1p3e10.3/)
return
end

subroutine septum_d_vol_func(nz,length,volume)
implicit none
integer nz
double precision length, volume
include 'septum.inc'
double precision septum_d_vol(septum_no_f_zones)
save septum_d_vol
data septum_d_vol/septum_no_f_zones*0.0d0/
integer NENTER, i
DATA NENTER/0/
SAVE NENTER
IF (NENTER.EQ.0) THEN
  NENTER = 1
  call septum_d_geo1
  call septum_subvol
  do i=1,septum_no_f_zones
    septum_d_vol(i)=vv(i) !! must multiply (length) later
  enddo
ENDIF
volume = 0.0d0
if ( nz .ge. 1 .and. nz .le. septum_no_f_zones ) then
  volume = septum_d_vol(nz) *length ! now multiplying (length)
endif
write(65,109) nz,volume,length,volume/length
109 format(12x,'septum_d ',i3,
  & ' volume,length,volume/length= ',1p3e10.3/)
return
end

subroutine septum_inj_vol_func(nz,length,volume)
implicit none
integer nz
double precision length, volume
include 'septum.inc'
double precision septum_inj_vol(septum_no_f_zones)
save septum_inj_vol
data septum_inj_vol/septum_no_f_zones*0.0d0/
integer NENTER, i
DATA NENTER/0/
SAVE NENTER
IF (NENTER.EQ.0) THEN
  NENTER = 1
  call septum_inj_geo1
  call septum_subvol
  do i=1,septum_no_f_zones
    septum_inj_vol(i)=vv(i) !! must multiply (length) later
  enddo
ENDIF
volume = 0.0d0
if ( nz .ge. 1 .and. nz .le. septum_no_f_zones ) then
  volume = septum_inj_vol(nz) *length ! now multiplying (length)
endif
write(65,109) nz,volume,length,volume/length
109 format(12x,'septum_inj ',i3,
  & ' volume,length,volume/length= ',1p3e10.3/)
return
end

subroutine septum_subvol
implicit none
include 'septum.inc'
include 'consts.inc'
integer i
do i=1,septum_no_f_zones
  vv(i)=0.0d0
enddo
C-----vacuum duct-----
IF (LD.eq.1) then ! rectangular duct
  vv(1)=se_duct_iw * se_duct_ih * 4.0d0
  vv(2)=se_duct_ow * se_duct_oh * 4.0d0 -vv(1)
else ! cylindrical duct
  vv(1)=pi * (se_duct_r)**2.0d0
  vv(2)=pi * (se_duct_thick)**2.0d0-vv(1)
ENDIF
C-----EM shield-----
vv(3)=(se_core_iw - se_deck_w) *se_deck_h *2.0d0
C-----inner core-----
vv(4)=(se_coil_ow - se_vac_w) *se_coil_h *2.0d0
vv(5)=(se_vac_w - se_coil_iw) *se_coil_h *2.0d0
vv(6)=(se_coil_iw - se_core_iw)*se_coil_h *2.0d0
C-----septum core-----
vv(7)=(se_coil_ow-se_core_iw)*(se_deck_h-se_coil_h)*2.0d0
vv(8)=(se_coil_ow-se_core_iw)*(se_core_h-se_deck_h)*2.0d0
vv(9) =(se_core_ow-se_coil_ow)*se_core_h
vv(10)=vv(9)
return
end

subroutine septum_a_geo1
implicit none
include 'septum.inc'
LD=0
se_duct_r = 12.5d0
se_duct_thick=13.0d0
se_deck_h = 12.0d0
se_deck_w = 9.0d0
se_vac_w = 24.0d0
se_coil_iw = 11.0d0
se_coil_ow = 27.0d0
se_coil_h = 8.5d0
se_core_iw = 9.5d0
se_core_ow = 45.0d0
se_core_h = 26.0d0
return
end

subroutine septum_b_geo1
implicit none
include 'septum.inc'
LD=0
se_duct_r = 12.5d0

```

```

se_duct_thick =13.0d0
se_deck_h = 12.0d0
se_deck_w = 10.5d0
se_vac_w = 30.0d0
se_coil_iw = 15.0d0
se_coil_ow = 39.0d0
se_coil_h = 7.5d0
se_core_iw = 11.0d0
se_core_ow = 67.0d0
se_core_h = 36.0d0
return
end

subroutine septum_c_geo1
implicit none
include 'septum.inc'
LD=0
se_duct_r =12.5d0
se_duct_thick =13.0d0
se_deck_h = 12.0d0
se_deck_w = 13.0d0
se_vac_w = 45.0d0
se_coil_iw = 25.0d0
se_coil_ow = 63.0d0
se_coil_h = 6.5d0
se_core_iw = 14.0d0
se_core_ow = 90.0d0
se_core_h = 50.0d0
return
end

subroutine septum_d_geo1
implicit none
include 'septum.inc'
LD=0
se_duct_r =12.5d0
se_duct_thick =13.0d0
se_deck_h = 12.0d0
se_deck_w = 13.0d0
se_vac_w = 58.0d0
se_coil_iw = 40.0d0
se_coil_ow = 78.0d0
se_coil_h = 6.0d0
se_core_iw = 20.0d0
se_core_ow = 136.0d0
se_core_h = 60.0d0
return
end

subroutine septum_inj_geo1
implicit none
include 'septum.inc'
LD=0
se_duct_r =10.0d0
se_duct_thick =11.5d0
se_deck_h = 15.0d0
se_deck_w = 11.5d0
se_vac_w = 20.0d0
se_coil_iw = 14.0d0
se_coil_ow = 24.0d0
se_coil_h = 3.0d0
se_core_iw = 12.5d0
se_core_ow = 38.0d0
se_core_h = 14.5d0
return
end

!
! kicker
!
subroutine kicker_l_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'KICKERL'
return
end

subroutine kicker_s_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'KICKERS'
return
end

subroutine kicker_init_func( type, name, ! type and name
$ length, pos, ! length and position
$ f ) ! field components
implicit none
character(*) type
character(*) name
double precision length, pos
double precision f(3)
!
! write(*,*) 'kicker ', name, ' have been initialized...'
return
end

subroutine kicker_l_geo_func( length,
$ x, y, z,
$ nz, lf )
implicit none
integer nz, lf
double precision length, x, y, z
include 'kicker.inc'
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
kick_core_h=15.5d0
kick_gap_h = 8.5d0
call kicker_subgeo(x,y,nz)
return
end

subroutine kicker_s_geo_func( length,
$ x, y, z,
$ nz, lf )
implicit none
integer nz, lf
double precision length, x, y, z
include 'kicker.inc'
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
kick_core_h=17.0d0
kick_gap_h=9.0d0
call kicker_subgeo(x,y,nz)
return
end

subroutine kicker_subgeo(x,y,nz)
implicit none
integer nz
double precision x, y, ax,ay
include 'kicker.inc'
nz = 0
ax=ABS(x)
ay=ABS(y)

C-----kicker chamber-----
if (x.ge. kick_cham_bottom .and. x.le. kick_cham_top) then
  if (ay.le. kick_cham_w) then
    nz= 5 !chamber STST
  end if
C-----vacuum-----
if (x.ge. kick_vac_bottom .and.
$ x.le. kick_vac_top) then
  if (ay.le. kick_vac_w) then
    nz= 4 !vacuum
  end if
C-----core-----
if ( ay .le. kick_core_w .and.
$ ay .ge. kick_slit ) then
  if ( ax .le. kick_core_h .and.
$ ax .ge. kick_gap_h ) then
    nz= 1 !kicker core up & down
    endif
  endif
  if ( ay .le. kick_core_w .and.
$ ay .ge. kick_gap_w ) then
    if ( ax .le. kick_gap_h ) then
      nz= 2 !kicker core right & left
      endif
    endif
  if ( ay .le. kick_gap_w .and.
$ ay .ge. kick_coil_w ) then
    if ( ax .le. kick_gap_h ) then
      nz= 3 !kicker coil
      endif
    endif
  endif
endif

```

```

        endif
    endif
endif
return
end

subroutine kicker_mat_func( nz, im )
implicit none
integer nz, im
include 'kicker.inc'
integer kicker_mat(kicker_nof_zones)
data kicker_mat/ 11, 14, 2, 0, 22/ ! kicker
c          YOKE,YOKE,COIL,void,STST
im = 0
if ( nz .ge. 1 .and. nz .le. kicker_nof_zones ) then
    im = kicker_mat(nz)
endif
return
end

subroutine kicker_field_func( length,
$                                f,
$                                x, y, z,
$                                bx, by, bz, bbb )
implicit none
double precision length, x, y, z
double precision bx, by, bz, bbb
double precision f(3)
*   double precision h, v, rq, r4, tmp
include 'kicker.inc'
bx = 0.0d0
by = 0.0d0
bz = 0.0d0
bbb = 0.0d0
return
end

subroutine kicker_l_vol_func( nz,
$                                length,
$                                volume )
implicit none
integer nz
double precision length, volume
include 'kicker.inc'
double precision kicker_l_vol(kicker_nof_zones)
save      kicker_l_vol
data kicker_l_vol/kicker_nof_zones*0.0d0/
integer NENTER, i
DATA NENTER/0/
SAVE NENTER
IF (NENTER.EQ.0) THEN
    NENTER = 1
    kick_core_h=15.5d0
    kick_gap_h = 8.5d0
    call kicker_subvol
    do i=1,kicker_nof_zones
        kicker_l_vol(i)=vvk(i)
    enddo
ENDIF
volume = 0.0d0
if ( nz .ge. 1 .and. nz .le. kicker_nof_zones ) then
    volume = kicker_l_vol(nz)* length
endif
write(65,109) nz,volume,length,volume/length
109 format(12x,'kicker_l ',i3,
&           ' volume,length,volume/length= ',1p3e10.3/)
return
end

subroutine kicker_s_vol_func(nz,length,volume )
implicit none
integer nz
double precision length, volume
include 'kicker.inc'
double precision kicker_s_vol(kicker_nof_zones)
save      kicker_s_vol
data kicker_s_vol/kicker_nof_zones*0.0d0/
integer NENTER, i
DATA NENTER/0/
SAVE NENTER
IF (NENTER.EQ.0) THEN
    NENTER = 1
    kick_core_h=17.0d0
    kick_gap_h=9.0d0
    call kicker_subvol
    do i=1,kicker_nof_zones
        kicker_s_vol(i)=vvk(i)
    enddo
ENDIF
volume = 0.0d0
if ( nz .ge. 1 .and. nz .le. kicker_nof_zones ) then
    volume = kicker_s_vol(nz) * length
endif
write(65,109) nz,volume,length,volume/length
109 format(12x,'kicker_s ',i3,
&           ' volume,length,volume/length= ',1p3e10.3/)
return
end

subroutine kicker_subvol
implicit none
include 'kicker.inc'
integer i
do i=1,kicker_nof_zones
    vvk(i)=0.0d0
enddo
vvk(1)=
& (kick_core_w-kick_slit)*(kick_core_h - kick_gap_h)*4.0d0
vvk(2)=(kick_core_w-kick_gap_w)*kick_gap_h*4.0d0
vvk(3)=(kick_gap_w-kick_coil_w)*kick_gap_h*4.0d0
vvk(4)=
& (kick_cham_top - kick_cham_bottom)*kick_cham_w*2.0d0
& -(kick_vac_top - kick_vac_bottom) *kick_vac_w *2.0d0
return
end

block data kicker_db
include 'kicker.inc'
data kick_core_w/22.8d0/
data kick_gap_w/16.0d0/
data kick_slit/1.0d0/
data kick_coil_w/14.0d0/
data kick_vac_top /50.0d0/
data kick_cham_top/52.0d0/
data kick_vac_bottom /-50.0d0/
data kick_cham_bottom/-52.0d0/
data kick_vac_w /50.0d0/
data kick_cham_w/52.0d0/
data kick_e_window_r/13.35d0/
end

```

B.4.6 Bump

```

!
! Bump
!

subroutine bump_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'BUMP'
return
end

subroutine bump_init_func( type, name, ! type and name
$                           length, pos, ! length and position
$                           f )                      ! field components
implicit none
character(*) type
character(*) name
double precision length, pos
double precision f(3)
! write(*,*) 'BUMP ', name, ' have been initialized...'
return
end

subroutine bump_geo_func( length,
$                           x, y, z,
$                           nz, lf )
implicit none
integer      nz, lf
double precision length, x, y, z
include 'bump.inc'
double precision ax,ay,r
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
nz = 0
ax=ABS(x)
ay=ABS(y)
r=SQRT(x*x+y*y)
C----- air in core -----
if ((ay.le.bump_gap_w).and.(ax.le.bump_coil_h)) then
c   nz = 3                      !air in the core
c   nz = 1                      !vacuum in the core
endif
C----- coil -----
if ((ay.le.bump_coil_w).and.(ax.le.bump_coil_h)) then
  nz = 4                      !bump coil
  return
endif
C-----bump core-----
if (y.ge.bump_core_left.and.y.le.bump_core_right) then
  if ((ax.le.bump_core_h1).and.(y.ge.bump_core_left1)) then
    nz = 5                      !core1(inner)
    return
  endif
  if (ax.le.bump_core_h) nz=6 !core(outer)
endif
C----- return
return
end

subroutine bump_mat_func( nz, im )
implicit none
integer nz, im
include 'bump.inc'
integer bump_mat(bump_noF_zones)
data bump_mat/0, 3, 19, 2, 14,18/ !BUMP
c           void,CRM,CRMC,AIR,COIL,YOKE,YOKE
im = 0
if ( nz .ge. 1 .and. nz .le. bump_noF_zones ) then
  im = bump_mat(nz)
endif
return
end

subroutine bump_field_func( length,
$                           f,
$                           x, y, z,
$                           bx, by, bz, bbb )
implicit none
double precision length, x, y, z
double precision bx, by, bz, bbb
double precision f(3)
*   double precision h, v, rq, r4, tmp
include 'bump.inc'
bx = 0.0d0
by = 0.0d0
bz = 0.0d0
bbb = 0.0d0
return
end

subroutine bump_vol_func( nz,
$                           length,
$                           volume )
implicit none
integer      nz
double precision length, volume, a2
include 'consts.inc'
include 'bump.inc'
double precision bump_vol(bump_noF_zones)
save          bump_vol

```

B.4.7 Collimator

```

!
! Collimator & target with concrete shield
!

subroutine col_1_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'COL1'
return
end

subroutine col_2_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'COL2'
return
end

subroutine col_3_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'COL3'
return
end

subroutine col_4_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'COL4'
return
end

subroutine col_5_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'COL5'
return
end

subroutine tar_1_name_func( type, name )
implicit none
character*80 type
character*80 name
type = 'DRIFT'
name = 'TAR1'
return
end

subroutine col_init_func( type, name, ! type and name
$                      length, pos, ! length and position
$                      f )          ! field components
implicit none
character(*) type
character(*) name
double precision length, pos
double precision f(3)
write(*,*) 'COL ', name, ' have been initialized...'
return
end

subroutine col_1_geo_func( length,
$                      x, y, z,
$                      nz, lf )
implicit none
integer      nz, lf
double precision length, x, y, z
include 'col.inc'
double precision ax,ay,r
nz = 0
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
hcol_position = 8.80d0
vcol_position = 5.55d0
itar=0
call col_subgeo(x,y,z,nz,length)
return
end

subroutine col_2_geo_func( length,
$                      x, y, z,
$                      nz, lf )
implicit none
integer      nz, lf
double precision length, x, y, z
include 'col.inc'
double precision ax,ay,r
nz = 0
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
hcol_position = 6.85d0
vcol_position = 8.20d0
itar=0
call col_subgeo(x,y,z,nz,length)
return
end

subroutine col_3_geo_func( length,
$                      x, y, z,
$                      nz, lf )
implicit none
integer      nz, lf
double precision length, x, y, z
include 'col.inc'
double precision ax,ay,r
nz = 0
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
hcol_position = 6.55d0
vcol_position = 7.50d0
itar=0
call col_subgeo(x,y,z,nz,length)
return
end

subroutine col_4_geo_func( length,
$                      x, y, z,
$                      nz, lf )
implicit none
integer      nz, lf
double precision length, x, y, z
include 'col.inc'
double precision ax,ay,r
nz = 0
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
hcol_position = 8.20d0
vcol_position = 5.20d0
itar=0
call col_subgeo(x,y,z,nz,length)
return
end

subroutine col_5_geo_func( length,
$                      x, y, z,
$                      nz, lf )
implicit none
integer      nz, lf
double precision length, x, y, z
include 'col.inc'
double precision ax,ay,r
nz = 0
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
hcol_position = 7.65d0
vcol_position = 5.00d0
itar=0
call col_subgeo(x,y,z,nz,length)
return
end

subroutine tar_1_geo_func( length,
$                      x, y, z,
$                      nz, lf )
implicit none
integer      nz, lf
double precision length, x, y, z
include 'col.inc'
double precision ax,ay,r
nz = 0
lf = 0
if ((z.lt.0.0d0).or.(z.gt.length)) return
lf = 1
hcol_position = 7.1486d0
vcol_position = 5.8590d0
itar=1
call col_subgeo(x,y,z,nz,length)
return
end

subroutine col_subgeo(x,y,zz,M,length)
implicit none
integer      M
double precision x,y,z,length,zz
double precision ax,ay,r
include 'col.inc'
ax=ABS(x)
ay=ABS(y)
if ((x.gt.outerconc_2+40.d0).or.
& (x.lt.-outerconc_2).or.(ay.gt.outerconc_2)) return
r=SQRT(x*x+y*y)
z=zz+15.d0 ! calibration
C-----pre stage (n=0)-----
if ( z .ge. 15 .and. z .le. 30 ) then
C-----side outer concrete-----
    if (ax .ge. outerconc_1 .and. ax .le. outerconc_2) then
        if (ay .le. outerconc_1) then
            M = 7 !concrete
        endif
        if (ax .ge. innerconc_size_2 .and. ax .le. outerconc_1) then
            if (ay .le. innerconc_size_2) then
                M = 8 !concrete
            endif
        endif
    endif
endif

```

```

-----top outer concrete-----
if (ay .ge. outerconc_1 .and. ay .le. outerconc_2) then
    if (ax .le. outerconc_2) then
        M = 9 !concrete
    endif
endif
if (ay .ge. innerconc_size_2 .and. ay .le. outerconc_1) then
    if (ax .le. outerconc_1) then
        M = 10 !concrete
    endif
endif
C-----inner concrete-----
if (ay .le. innerconc_size_2) then
    if (ax .le. innerconc_size_2) then
        M = 11 !concrete
    if (ay .le. innerconc_size_1) then
        if (ax .le. innerconc_size_1) then
            M = 12 !concrete
C-----vacuum-----
if (r .le. beam_port_r) then
    M = 1 !vacuum
endif
endif
endif
C-----stage 1-1 (n=1)-----
if (z .ge. 30 .and. z .le. 45) then
C-----side outer concrete-----
if (ax .ge. outerconc_1 .and. ax .le. outerconc_2) then
    if (ay .le. outerconc_1) then
        M = 22 !concrete
    endif
if (ax .ge. innerconc_size_2 .and. ax .le. outerconc_1) then
    if (ay .le. innerconc_size_2) then
        M = 23 !concrete
    endif
endif
C-----top outer concrete-----
if (ay .ge. outerconc_1 .and. ay .le. outerconc_2) then
    if (ax .le. outerconc_2) then
        M = 24 !concrete
    endif
endif
if (ay .ge. innerconc_size_2 .and. ay .le. outerconc_1) then
    if (ax .le. outerconc_1) then
        M = 25 !concrete
    endif
endif
C-----inner concrete-----
if (ay .le. innerconc_size_2) then
    if (ax .le. innerconc_size_2) then
        M = 26 !concrete
    endif
endif
C-----inner iron-----
if (ay .le. inneriron_size_2) then
    if (ax .le. inneriron_size_2) then
        M = 18 !iron
    endif
endif
if (ay .le. inneriron_size_1) then
    if (ax .le. inneriron_size_1) then
        M = 19 !iron
C-----vacuum-----
if (r .le. beam_port_r) then
    M = 16 !vacuum
endif
endif
endif
C-----stage 1-2 (n=2)-----
if (z .ge. 45 .and. z .le. 55) then
C-----side outer concrete-----
if (ax .ge. outerconc_1 .and. ax .le. outerconc_2) then
    if (ay .le. outerconc_1) then
        M = 37 !concrete
    endif
endif
if (ax .ge. innerconc_size_2 .and. ax .le. outerconc_1) then
    if (ay .le. innerconc_size_2) then
        M = 38 !concrete
    endif
endif
C-----top outer concrete-----
if (ay .ge. outerconc_1 .and. ay .le. outerconc_2) then
    if (ax .le. outerconc_2) then
        M = 39 !concrete
    endif
endif
if (ay .ge. innerconc_size_2 .and. ay .le. outerconc_1) then
    if (ax .le. outerconc_1) then
        M = 40 !concrete
    endif
endif
C-----inner concrete-----
if (ay .le. innerconc_size_2) then
    if (ax .le. innerconc_size_2) then
        M = 41 !concrete
C-----inner iron-----
if (ay .le. inneriron_size_2) then
    if (ax .le. inneriron_size_2) then
        M = 33 !iron
C-----vacuum-----
if (ay .le. inneriron_size_1) then
    if (ax .le. inneriron_size_1) then
        M = 34 !iron
endif
endif
endif
C-----stage 2 (n=3)-----
c
if (z .ge. 55 .and. z .le. 60) then
C-----side outer concrete-----
if (ax .ge. outerconc_1 .and. ax .le. outerconc_2) then
    if (ay .le. outerconc_1) then
        M = 52 !concrete
    endif
endif
if (ay .ge. innerconc_size_2 .and. ax .le. outerconc_1) then
    if (ay .le. innerconc_size_2) then
        M = 53 !concrete
    endif
endif
C-----top outer concrete-----
if (ay .ge. outerconc_1 .and. ay .le. outerconc_2) then
    if (ax .le. outerconc_2) then
        M = 54 !concrete
    endif
endif
if (ay .ge. innerconc_size_2 .and. ay .le. outerconc_1) then
    if (ax .le. outerconc_1) then
        M = 55 !concrete
    endif
endif
C-----inner concrete-----
if (ay .le. innerconc_size_2) then
    if (ax .le. innerconc_size_2) then
        M = 56 !concrete
C-----inner iron-----
if (ay .le. inneriron_size_2) then
    if (ax .le. inneriron_size_2) then
        M = 48 !iron
        if (ay .le. inneriron_size_1) then
            if (ax .le. inneriron_size_1) then
                M = 49 !iron
C-----vacuum-----
if (ax .le. chamber_size) then
    if (ay .le. chamber_size) then
        M = 46 !vacuum
    endif
endif
endif
endif
endif
C-----stage 3 (n=4)-----
if (z .ge. 60 .and. z .le. 80) then
    if (ax .le. 80) then
        if (ay .le. col_port_size) then
            M = 61 !vacuum
        endif
    endif
    if (ay .le. 80) then
        if (ax .le. col_port_size) then
            M = 61 !vacuum
        endif
    endif
C-----side outer concrete-----
if (ax .ge. outerconc_1 .and. ax .le. outerconc_2) then
    if (ay .ge. col_port_size .and. ay .le. outerconc_1) then
        M = 67 !concrete
    endif
endif
if (ay .ge. innerconc_size_2 .and. ax .le. outerconc_1) then
    if (ay .ge. col_port_size .and. ay .le. innerconc_size_2) then
        M = 68 !concrete
    endif
endif
C-----top outer concrete-----
if (ay .ge. outerconc_1 .and. ay .le. outerconc_2) then
    if (ax .ge. col_port_size .and. ax .le. outerconc_2) then
        M = 69 !concrete
    endif
endif
if (ay .ge. innerconc_size_2 .and. ay .le. outerconc_1) then
    if (ay .ge. col_port_size .and. ax .le. outerconc_1) then
        M = 70 !concrete
    endif
endif
C-----inner concrete-----
if (ay .le. innerconc_size_2) then

```

```

if (ax .le. innerconc_size_2) then
  M = 71          !concrete
endif
endif

if (ay .le. innerconc_size_1) then
  if (ax .le. innerconc_size_1) then
    M = 72          !concrete
  endif
endif
endif

C-----inner iron-----
if (ay .le. inneriron_size_2) then
  if (ax .le. inneriron_size_2) then
    M = 86          !concrete
  endif
C-----inner iron-----
if (ay .le. inneriron_size_2) then
  if (ax .le. inneriron_size_2) then
    M = 78          !iron
  if (ay .le. inneriron_size_1) then
    if (ax .le. inneriron_size_1) then
      M = 79 !iron
  endif
endif
endif
endif

C-----vacuum-----
if (ay .le. chamber_size) then
  if (ay .le. chamber_size) then
    M = 76 !vacuum
  endif
endif
endif
endif

C-----stage 5-1 (n=6)-----
if ( z .ge. 85 .and. z .le. 95 ) then
C-----side outer concrete-----
if (ax .ge. outerconc_1 .and. ax .le. outerconc_2) then
  if (ay .le. outerconc_1) then
    M = 97          !concrete
  endif
  if (ax .ge. innerconc_size_2 .and. ax .le. outerconc_1) then
    if (ay .le. innerconc_size_2) then
      M = 98          !concrete
    endif
  endif
endif
endif

C-----top outer concrete-----
if (ay .ge. outerconc_1 .and. ay .le. outerconc_2) then
  if (ax .le. outerconc_2) then
    M = 99          !concrete
  endif
  if (ay .ge. innerconc_size_2 .and. ay .le. outerconc_1) then
    if (ax .le. outerconc_1) then
      M = 100          !concrete
    endif
  endif
endif

C-----inner concrete-----
if (ay .le. innerconc_size_2) then
  if (ax .le. innerconc_size_2) then
    M = 101          !concrete
  endif
endif

C-----inner iron-----
if (ay .le. inneriron_size_2) then
  if (ax .le. inneriron_size_2) then
    M = 93          !iron
  if (ay .le. inneriron_size_1) then
    if (ax .le. inneriron_size_1) then
      M = 94 !iron
  endif
endif
endif

C-----vacuum-----
if (r .le. beam_port_r) then
  M = 91 !vacuum
endif
endif
endif
endif

C-----stage 5-2 (n=7)-----
if ( z .ge. 95 .and. z .le. 105 ) then
C-----side outer concrete-----
if (ax .ge. outerconc_1 .and. ax .le. outerconc_2) then
  if (ay .le. outerconc_1) then
    M = 112          !concrete
  endif
  if (ax .ge. innerconc_size_2 .and. ax .le. outerconc_1) then
    if (ay .le. innerconc_size_2) then
      M = 113          !concrete
    endif
  endif
endif
endif

C-----top outer concrete-----
if (ay .ge. outerconc_1 .and. ay .le. outerconc_2) then
  if (ax .le. outerconc_2) then
    M = 114          !concrete
  endif
  if (ay .ge. innerconc_size_2 .and. ay .le. outerconc_1) then
    if (ax .le. outerconc_1) then
      M = 115          !concrete
    endif
  endif
endif

C-----inner concrete-----
if (ay .le. innerconc_size_2) then
  if (ax .le. innerconc_size_2) then
    M = 116          !concrete
  endif
endif

C-----inner iron-----
if (ay .le. inneriron_size_2) then
  if (ax .le. inneriron_size_2) then
    M = 108          !iron
  if (ay .le. inneriron_size_1) then
    if (ax .le. inneriron_size_1) then
      M = 109 !iron
    endif
  endif
endif
endif

C-----vacuum-----

```

```

        endif
    endif
    if (ax .ge. innerconc_size_2 .and. ax .le. outerconc_1) then
        if (ay .le. innerconc_size_2) then
            M = 158 !concrete
        endif
    endif
C-----top outer concrete-----
    if (ay .ge. outerconc_1 .and. ay .le. outerconc_2) then
        if (ax .le. outerconc_2) then
            M = 159 !concrete
        endif
    endif
    if (ay .ge. innerconc_size_2 .and. ay .le. outerconc_1) then
        if (ax .le. outerconc_1) then
            M = 160 !concrete
        endif
    endif
endif

C-----inner concrete-----
    if (ay .le. innerconc_size_2) then
        if (ax .le. innerconc_size_2) then
            M = 161 !concrete

            if (ay .le. innerconc_size_1) then
                if (ax .le. innerconc_size_1) then
                    M = 162 !concrete

C-----vacuum-----
        if (r .le. beam_port_r) then
            M = 151 !vacuum
        endif
    endif
    endif
endif

C-----after stage 3 (n=11)-----
if (z .ge. 140 .and. z .le. 150) then
C-----side outer concrete-----
    if (ax .ge. outerconc_1 .and. ax .le. outerconc_2) then
        if (ay .le. outerconc_1) then
            M = 172 !concrete
        endif
    endif
    if (ax .ge. innerconc_size_2 .and. ax .le. outerconc_1) then
        if (ay .le. innerconc_size_2) then
            M = 173 !concrete
        endif
    endif
endif

C-----top outer concrete-----
    if (ay .ge. outerconc_1 .and. ay .le. outerconc_2) then
        if (ax .le. outerconc_2) then
            M = 174 !concrete
        endif
    endif
    if (ay .ge. innerconc_size_2 .and. ay .le. outerconc_1) then
        if (ax .le. outerconc_1) then
            M = 175 !concrete
        endif
    endif
endif

C-----inner concrete-----
    if (ay .le. innerconc_size_2) then
        if (ax .le. innerconc_size_2) then
            M = 176 !concrete

            if (ay .le. innerconc_size_1) then
                if (ax .le. innerconc_size_1) then
                    M = 177 !concrete

C-----vacuum-----
        if (r .le. beam_port_r) then
            M = 166 !vacuum
        endif
    endif
    endif
endif

C-----*** iron cap (NAKAO 2001-NOV-24)
*** iron cap (NAKAO 2001-NOV-24)

        if (x.ge.outerconc_2) M=180 ! iron

        return
    end

subroutine col_mat_func( nz, im )
implicit none
integer nz, im
include 'col.inc'
integer col_mat(col_nof_zones)
data col_mat/
C 19='AIR' 8='FE' 6='CU' 4='CONC' 27='W'
$ 0, 19, 8, 8, 6, 6, 7*4, 0, 0,
$ 0, 19, 8, 8, 6, 6, 7*4, 0, 0,
$ 0, 19, 8, 8, 6, 6, 7*4, 0, 0,
$ 0, 19, 8, 8, 6, 6, 7*4, 0, 0,
$ 0, 19, 8, 8, 6, 6, 7*4, 27, 27,
$ 0, 19, 8, 8, 6, 6, 7*4, 0, 0,
$ 0, 19, 8, 8, 6, 6, 7*4, 0, 0,
$ 0, 19, 8, 8, 6, 6, 7*4, 0, 0,
```

```

$      0, 19, 8, 8, 6, 6, 7*4, 0, 0,
$      0, 19, 8, 8, 6, 6, 7*4, 0, 0,
$      0, 19, 8, 8, 6, 6, 7*4, 0, 0,
$      0, 19, 8, 8, 6, 6, 7*4, 0, 8/
im = 0
if ( nz .ge. 1 .and. nz .le. col_nof_zones ) then
  im = col_mat(nz)
endif
return
end

subroutine col_field_func( length,
$                           f,
$                           x, y, z,
$                           bx, by, bz, bbb )
implicit none
double precision length, x, y, z
double precision bx, by, bz, bbb
double precision f(3)
* double precision h, v, rq, r4, tmp
include 'col.inc'
bx = 0.0d0
by = 0.0d0
bz = 0.0d0
bbb = 0.0d0
return
end

subroutine col_1_vol_func(nz,length,volume)
implicit none
integer nz
double precision length, volume,px,py
px=0.0d0
py=1.0d0
call col_subvol(nz,length,volume,px,py)
return
end

subroutine col_vol_func(nz,length,volume)
implicit none
integer nz
double precision length, volume,px,py
px=1.0d0
py=1.0d0
call col_subvol(nz,length,volume,px,py)
return
end

subroutine col_subvol(nz,length,vol,px,py)
implicit none
integer      nz,nnn,N1
double precision length, vol
double precision chamin,chamout,pipe,coll,px,py
include 'consts.inc'
include 'col.inc'
double precision volume(col_nof_zones)
save          volume
data volume/col_nof_zones*0.0d0/
data N1/0/
INTEGER NENTER
data NENTER/0/
SAVE NENTER
IF (NENTER.eq.0) THEN
VOLUME(N1+1) =PI*10.D0*10.D0*10.D0
VOLUME(N1+5) =90.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+6) =80.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+7) =70.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+8) =60.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+9) =80.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+10) =70.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+11) =60.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+12) =50.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+13) =100.D0*100.D0*10.D0-PI*10.D0*10.D0*10.D0
VOLUME(N1+16) =PI*10.D0*10.D0*25.D0
VOLUME(N1+19) =60.D0*60.D0*25.D0-PI*10.D0*10.D0*25.D0
VOLUME(N1+20) =90.D0*2.D0*10.D0*2.D0*25.D0
VOLUME(N1+21) =80.D0*2.D0*10.D0*2.D0*25.D0
VOLUME(N1+22) =70.D0*2.D0*10.D0*2.D0*25.D0
VOLUME(N1+23) =60.D0*2.D0*10.D0*2.D0*25.D0
VOLUME(N1+24) =80.D0*2.D0*10.D0*2.D0*25.D0
VOLUME(N1+25) =70.D0*2.D0*10.D0*2.D0*25.D0
VOLUME(N1+26) =60.D0*2.D0*10.D0*2.D0*25.D0
VOLUME(N1+27) =50.D0*2.D0*10.D0*2.D0*25.D0
VOLUME(N1+28) =100.D0*100.D0*25.D0-60.D0*60.D0*25.D0
VOLUME(N1+31) =30.D0*30.D0*5.3D0
VOLUME(N1+34) =60.D0*60.D0*5.3D0-30.D0*30.D0*5.3D0
VOLUME(N1+35) =90.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+36) =80.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+37) =70.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+38) =60.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+39) =80.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+40) =70.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+41) =60.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+42) =50.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+43) =100.D0*100.D0*5.3D0-60.D0*60.D0*5.3D0
VOLUME(N1+46) =28.D0*160.D0*9.D0*28.D0*132.D0*9.D0-12.D0*10.D0*9.0D0
VOLUME(N1+48) =12.D0*10.D0*9.0D0
VOLUME(N1+49) =16.D0*16.D0*9.D0*4.D0
VOLUME(N1+50) =90.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+51) =80.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+52) =70.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+53) =60.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+54) =80.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+55) =70.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+56) =60.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+57) =50.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+58) =36.D0*36.D0*9.D0*4.D0-16.D0*16.D0*9.D0*4.D0
VOLUME(N1+61) =28.D0*160.D0*2.D0*28.D0*132.D0*2.D0-VOLUME(N1+63)
VOLUME(N1+63) =46.07D0*10.D0*2.0*2.0+42.04D0*10.D0*2.0*2.0
VOLUME(N1+64) =16.D0*16.D0*2.D0*4.D0
VOLUME(N1+65) =90.D0*2.D0*10.D0*2.D0*2.D0
VOLUME(N1+66) =80.D0*2.D0*10.D0*2.D0*2.D0
VOLUME(N1+67) =70.D0*2.D0*10.D0*2.D0*2.D0
VOLUME(N1+68) =60.D0*2.D0*10.D0*2.D0*2.D0
VOLUME(N1+69) =80.D0*2.D0*10.D0*2.D0*2.D0
VOLUME(N1+70) =70.D0*2.D0*10.D0*2.D0*2.D0
VOLUME(N1+71) =60.D0*2.D0*10.D0*2.D0*2.D0
VOLUME(N1+72) =50.D0*2.D0*10.D0*2.D0*2.D0
VOLUME(N1+73) =36.D0*36.D0*2.D0*4.D0-16.D0*16.D0*2.D0*4.D0
VOLUME(N1+76) =28.D0*160.D0*9.D0*28.D0*132.D0*9.D0-12.D0*10.D0*9.0D0
VOLUME(N1+78) =12.D0*10.D0*9.0D0
VOLUME(N1+79) =16.D0*16.D0*9.D0*4.D0
VOLUME(N1+80) =90.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+81) =80.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+82) =70.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+83) =60.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+84) =80.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+85) =70.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+86) =60.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+87) =50.D0*2.D0*10.D0*2.D0*9.D0
VOLUME(N1+88) =36.D0*36.D0*9.D0*4.D0-16.D0*16.D0*9.D0*4.D0
VOLUME(N1+91) =30.D0*30.D0*5.3D0
VOLUME(N1+94) =60.D0*60.D0*5.3D0-30.D0*30.D0*5.3D0
VOLUME(N1+95) =90.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+96) =80.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+97) =70.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+98) =60.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+99) =80.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+100) =70.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+101) =60.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+102) =50.D0*2.D0*10.D0*2.D0*5.3D0
VOLUME(N1+103) =100.D0*100.D0*5.3D0-60.D0*60.D0*5.3D0
VOLUME(N1+106) =PI*10.D0*10.D0*15.D0
VOLUME(N1+109) =60.D0*60.D0*15.D0-PI*10.D0*10.D0*15.D0
VOLUME(N1+110) =90.D0*2.D0*10.D0*2.D0*15.D0
VOLUME(N1+111) =80.D0*2.D0*10.D0*2.D0*15.D0
VOLUME(N1+112) =70.D0*2.D0*10.D0*2.D0*15.D0
VOLUME(N1+113) =60.D0*2.D0*10.D0*2.D0*15.D0
VOLUME(N1+114) =80.D0*2.D0*10.D0*2.D0*15.D0
VOLUME(N1+115) =70.D0*2.D0*10.D0*2.D0*15.D0
VOLUME(N1+116) =60.D0*2.D0*10.D0*2.D0*15.D0
VOLUME(N1+117) =50.D0*2.D0*10.D0*2.D0*15.D0
VOLUME(N1+118) =100.D0*100.D0*15.D0-60.D0*60.D0*15.D0
VOLUME(N1+121) =PI*10.D0*10.D0*10.D0
VOLUME(N1+124) =60.D0*60.D0*10.D0-PI*10.D0*10.D0*10.D0
VOLUME(N1+125) =90.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+126) =80.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+127) =70.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+128) =60.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+129) =80.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+130) =70.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+131) =60.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+132) =50.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+133) =100.D0*100.D0*10.D0-60.D0*60.D0*10.D0
VOLUME(N1+136) =PI*10.D0*10.D0*10.D0
VOLUME(N1+140) =90.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+141) =80.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+142) =70.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+143) =60.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+144) =80.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+145) =70.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+146) =60.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+147) =50.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+148) =100.D0*100.D0*10.D0-PI*10.D0*10.D0*10.D0
VOLUME(N1+151) =PI*10.D0*10.D0*10.D0
VOLUME(N1+155) =90.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+156) =80.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+157) =70.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+158) =60.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+159) =80.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+160) =70.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+161) =60.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+162) =50.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+163) =100.D0*100.D0*10.D0-PI*10.D0*10.D0*10.D0
VOLUME(N1+166) =PI*10.D0*10.D0*10.D0
VOLUME(N1+170) =90.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+171) =80.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+172) =70.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+173) =60.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+174) =80.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+175) =70.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+176) =60.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+177) =50.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+178) =100.D0*100.D0*10.D0-PI*10.D0*10.D0*10.D0
VOLUME(N1+181) =PI*10.D0*10.D0*10.D0
VOLUME(N1+185) =90.D0*2.D0*10.D0*2.D0*10.D0

```

```

VOLUME(N1+186) =80.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+187) =70.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+188) =60.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+189) =80.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+190) =70.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+191) =60.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+192) =50.D0*2.D0*10.D0*2.D0*10.D0
VOLUME(N1+193) =100.D0*100.D0*10.D0-PI*10.D0*10.D0*10.

ENDIF
vol = 0.0d0
if ( nz .ge. 1 .and. nz .le. col_noof_zones ) then
  vol = volume(nz)
endif
write(65,109) nz,vol
109 format(i2x,'collimator ',i3,1pe10.3/)
return
end

```

B.5 Detector volume

```

SUBROUTINE VFAN( N, V )
IMPLICIT DOUBLE PRECISION (A-H,O-Z), INTEGER (I-N)
C.....  

C   FIND VOLUME  V(N),CM**3 OF REGION N OF THE NON-STANDARD GEOMETRY  

C   VOLUME(N) ARE DEFINED IN SERV FOR N <= NFZP  

C  

C   REVISION: 21-DEC-1998 BY NVM  

C.....  

COMMON /BLREG1/ INUG, NFZP, NFZPEX, NPL, NZI, NCELMX  

INCLUDE 'tally1.inc'  

DATA NENTER/0/  

SAVE NENTER  

C   PARAMETER (PI=3.141592653589793227D+00)  

C   PARAMETER (RCOL=1.70D0)  

C-----  

N1 = NFZPEX ! NUMBER OF STANDARD+EXTENDED REGIONS  

IF ( NENTER .EQ. 0 ) THEN  

    NENTER = 1  

    call blmaxmat( nzmaxbl )  

    do i = 1, nzmaxbl  

        call blvol( i, volume(ni+i) )  

    enddo  

C== PUT HERE THE REAL VOLUMES (CM**3) FOR ALL THE NEEDED ====  

C   NON-STANDARD REGIONS <= M_MAX, I.E. REDEFINE ANY OF THE  

C   PRE-DEFINED VOLUME(L) = 0.D0  

C   For example:  

C  

C       VOLUME(N1+2) = PI*RCOL*RCOL*180.D0  

C       VOLUME(N1+3) = PI*(400.D0-RCOL*RCOL)*60.D0  

C       VOLUME(N1+365)= VOLUME(N1+3)  

C=====  

ENDIF  

V = VOLUME(N)  

RETURN  

END

```

B.6 Magnetic field

```

subroutine field( n, x, y, z , bx, by, bz, bbb )
implicit none
integer n
double precision x, y, z , bx, by, bz, bbb
C.....  

C FINDS COMPONENTS OF MAGNETIC FIELD
C INPUT: MAG -MAGNETIC INDEX AT THE GIVEN POINT
C X,Y,Z - POINT'S COORDINATES (OPTIONAL)
C FIELD MAPS
C QUADS GRADIENTS IN T/CM
C OUTPUT: BX,BY,BZ,BBB IN TESLA
C BBB=SQRT(BX*BX+BY*BY+BZ*BZ)
C
C REVISION: 15-JUN-1998
C
C G>0 FOR FOC QUADS, G<0 FOR DEFOC QUADS
C.....  

bx = 0.0d0
by = 0.0d0
bz = 0.0d0
bbb = 0.0d0
call blfield( x, y, z , bx, by, bz, bbb )
return
end

SUBROUTINE SUFI
IMPLICIT DOUBLE PRECISION (A-H,O-Z), INTEGER (I-N)
C.....  

C READS MAGNETIC FIELD MAP
C
C SUFI (OPEN & CLOSE):
C
C BEND.MAP (UNIT=21) IS FOR B=+1.1 T at 3GeV
C QUAD.MAP (UNIT=22) IS FOR G=+4.5 T/M at 3GeV Bohr radius 270mm
C LQUAD.MAP (UNIT=23) IS FOR G=+3.8 T/M at 3GeV Bohr radius 330mm
C
C MAP : Y - UP, X - RIGHT
C MARS: X - UP, Y - RIGHT
C
C REVISION: 13-MAR-2001
C REVISION: 24-MAY-2001 by Nakao for JKK 3GeV
C.....  

* & /BMMAP/BXB(141,119),BYB(141,119),XBM(141),YBM(119),DLXB,DLYB
* & /QMMAP/BXQ(129,177),BYQ(129,177),XQM(129),YQM(177),DLXQ,DLYQ
COMMON
& /BMMAP/BXB(150,150),BYB(150,150),XBM(150),YBM(150),DLXB,DLYB
& /QMMAP/BXQ(180,180),BYQ(180,180),XQM(180),YQM(180),DLXQ,DLYQ
& /LMMAP/BXL(180,180),BYL(180,180),XLM(180),YLM(180),DLXL,DLYL
& /FMPSZ/NXB,NYB,NXQ,NYQ,NXL,NYL  

C-----  

LUNB=21
LUNQ=22
LUNL=23
OPEN (UNIT=LUNB, FILE='..../field/BEND.MAP', STATUS='OLD')
OPEN (UNIT=LUNQ, FILE='..../field/QUAD.MAP', STATUS='OLD')
OPEN (UNIT=LUNL, FILE='..../field/LQUAD.MAP', STATUS='OLD')
NYB=140
NXB=118
NYQ=128
NXQ=176
NYL=128
NXL=176
c
c bin width of MAP to be read
c bend
DLXB= 0.5D0
DLYB= 0.5D0
C Quad 270
DLXB=0.25D0
DLYB= 0.5D0
C Quad 330
DLXL=0.25D0
DLYL= 0.5D0
c
NLPBM=150
DO I=1,NLPBM
D2=DBLE(I-1)
XBM(I)=D2*DLXB
YBM(I)=D2*DLYB
DO I1=1,NLPBM
BXB(I1,I)=0.D0
BYB(I1,I)=0.D0
END DO
NLPQM=180
DO I=1,NLPQM
D2=DBLE(I-1)
XQM(I)=D2*DLXQ
YQM(I)=D2*DLYQ
DO I1=1,NLPQM
BXQ(I1,I)=0.D0
BYQ(I1,I)=0.D0
END DO
NLPLM=180
DO I=1,NLPLM
D2=DBLE(I-1)
XLM(I)=D2*DLXL
YLM(I)=D2*DLYL
DO I1=1,NLPLM
BXL(I1,I)=0.D0
BYL(I1,I)=0.D0
END DO
END
C===
MAP-TO-MARS REVERSE ===
IX=INT(YY/DLYB)+1
IY=INT(XX/DLXB)+1
BXB(IX,IY)=BYY ! Temporary
BYB(IX,IY)=BXX ! Temporary
go to 1
2 read(LUNB,* ,end=2) xx,yy,bxx,byy
C===
MAP-TO-MARS REVERSE ===
IX=INT(YY/DLXB)+1
IY=INT(XX/DLYB)+1
BXQ(IX,IY)=-BYY ! Temporary
BYQ(IX,IY)=-BXX ! Temporary
go to 2
3 read(LUNL,* ,end=4) xx,yy,bxx,byy
C===
MAP-TO-MARS REVERSE ===
IX=INT(YY/DLXL)+1
IY=INT(XX/DLYL)+1
BXL(IX,IY)=-BYY ! Temporary
BYL(IX,IY)=-BXX ! Temporary
go to 3
4 continue
CLOSE(UNIT=LUNB)
CLOSE(UNIT=LUNQ)
CLOSE(UNIT=LUNL)
RETURN
END

SUBROUTINE LITWOD(XX,YY,LL,IXY,FOUT)
IMPLICIT DOUBLE PRECISION (A-H,O-Z), INTEGER (I-N)
C
LL=1: BM
C
LL=2: QM
C
LL=3: LQM
C
IXY=1 -> BX
C
IXY=2 -> BY
* Linearly interpolates a value from a two-dimensional mesh
C-----
C LAST CHANGE: 13-MAR-2001 BY NVM
C-----
COMMON
& /BMMAP/BXB(150,150),BYB(150,150),XBM(150),YBM(150),DLXB,DLYB
& /QMMAP/BXQ(180,180),BYQ(180,180),XQM(180),YQM(180),DLXQ,DLYQ
& /LMMAP/BXL(180,180),BYL(180,180),XLM(180),YLM(180),DLXL,DLYL
& /FMPSZ/NXB,NYB,NXQ,NYQ,NXL,NYL
C-----  

FOUT=0.0D0
IF(XX.LT.0.D0) RETURN
IF(YY.LT.0.D0) RETURN
M=LL
IF(M.EQ.1) THEN
DO IX=1,NXB
IF(XX.LE.XBM(IX+1)) GO TO 1
END DO
RETURN
1 DO IY=1,NYB
IF(YY.LE.YBM(IY+1)) GO TO 2
END DO
RETURN
2 X1=XBM(IX)
X2=XBM(IX+1)
Y1=YBM(IY)
Y2=YBM(IY+1)
XX1=XX-X1
XX2=X2-X1
IF(IXY.EQ.1) THEN
F1=BXB(IX,IY) +XX1*(BXB(IX+1,IY) -BXB(IX,IY))/XX2
F2=BXB(IX,IY+1)+XX1*(BXB(IX+1,IY+1)-BXB(IX,IY+1))/XX2
ELSE
F1=BYB(IX,IY) +XX1*(BYB(IX+1,IY) -BYB(IX,IY))/XX2
F2=BYB(IX,IY+1)+XX1*(BYB(IX+1,IY+1)-BYB(IX,IY+1))/XX2
END IF
ELSE IF(M.EQ.2) THEN
DO IX=1,NXQ
IF(XX.LE.XQM(IX+1)) GO TO 3
END DO
RETURN
3 DO IY=1,NYQ
IF(YY.LE.YQM(IY+1)) GO TO 4
END DO
RETURN
4 X1=XQM(IX)
X2=XQM(IX+1)
Y1=YQM(IY)
Y2=YQM(IY+1)
XX1=XX-X1
XX2=X2-X1
IF(IXY.EQ.1) THEN
F1=BXQ(IX,IY) +XX1*(BXQ(IX+1,IY) -BXQ(IX,IY))/XX2
F2=BXQ(IX,IY+1)+XX1*(BXQ(IX+1,IY+1)-BXQ(IX,IY+1))/XX2
ELSE
F1=BYQ(IX,IY) +XX1*(BYQ(IX+1,IY) -BYQ(IX,IY))/XX2
F2=BYQ(IX,IY+1)+XX1*(BYQ(IX+1,IY+1)-BYQ(IX,IY+1))/XX2
END IF
ELSE IF(M.EQ.3) THEN
DO IX=1,NXL
IF(XX.LE.XLM(IX+1)) GO TO 5
END DO
RETURN
5

```

```

5      DO IY=1,NYL
6         IF(YY.LE.YLM(IY+1)) GO TO 6
7         END DO
8         RETURN
9
10        X1=XLM(IX)
11        X2=XLM(IX+1)
12        Y1=YLM(IY)
13        Y2=YLM(IY+1)
14        XX1=XX-X1
15        XX2=X2-X1
16        IF(IXY.EQ.1) THEN
17           F1=BXL(IX,IY) +XX1*(BXL(IX+1,IY) -BXL(IX,IY))/XX2
18           F2=BXL(IX,IY+1)+XX1*(BXL(IX+1,IY+1)-BXL(IX,IY+1))/XX2
19        ELSE
20           F1=BYL(IX,IY) +XX1*(BYL(IX+1,IY) -BYL(IX,IY))/XX2
21           F2=BYL(IX,IY+1)+XX1*(BYL(IX+1,IY+1)-BYL(IX,IY+1))/XX2
22        END IF
23
24        FOUT=F1+(YY-Y1)*(F2-F1)/(Y2-Y1)
25        RETURN
26
27 END
```

B.7 Source Term(BEG1)

B.7.1 Source at the injection and collimator region

4kW distributed source at the collimator region which is calculated with STRUCT code, and 1kW source at the injection septum.

```

subroutine beg1(JJ,W,E,X,Y,Z,DCX,DCY,DCZ,TOFF,INTA,NREG1)
implicit none
integer JJ, INTA, NREG1
double precision W,E,X,Y,Z,DCX,DCY,DCZ,TOFF
integer NI,NSTOP,NUPRI,NHIPR
COMMON/HIST/NI,NSTOP,NUPRI,NHIPR
C.....RE-DEFINES EACH OR ANY OF THE 10 PARAMETERS
C.....OF INITIAL SOURCE PARTICLES
C.....ARRANGE A POINT-LIKE INTERACTION IF INTA=1
C.....PARTICLE TAGGING IN 'MTAGG' SOURCE ZONES OF 'ETGG' ENERGY
C.....INTERVALS FOR 'NTAGG' DETECTOR ZONES
C.....DEFAULTS: NUMTAG=6, MTAGG=0, INTAG=1, IETAG=4
C.....REVISION: 09-MAR-2001
C.....C++ INSERT YOUR SOURCE TERM HERE ++
C== SOURCE PARTICLE READING FROM STRUCT-OUTPUT =====
double precision XX,YY
double precision ZZ1,ZZ2,tun_length
DATA XX/0.d0/
DATA YY/13.8d0/
DATA ZZ1,ZZ2/34207.4d0, 34287.4d0/
DATA tun_length /34833.3d0/
double precision dz,zc,rand
double precision pos(3),dir(3),pos0,length,bmlparams
external bmlparams
INTEGER NENTER
DATA NENTER/0/
SAVE NENTER, pos0, length
integer number,numsep
double precision x00,y00,z00
common/nakao/x00,y00,z00,number
INTEGER ncount
DATA ncount/0/
IF ( NENTER .EQ. 0 ) THEN
   NENTER = 1
C ===== OPEN STRUCT-OUTPUT FILE =====NAKAO=====
OPEN (UNIT=7,FILE='../../src/PAR92_9b10_400mev_injcol.bloss')
C =====
pos0=bmlparams( 1 )
length=bmlparams( 2 )
write(*,*) 'Source BEG1: pos0 =', pos0
write(*,*) 'Source BEG1: beam line length =', length
dz=ZZ2-ZZ1
zc=ZZ1-pos0
write(*,*) 'Source BEG1: pos0 =', pos0
write(*,*) 'Source BEG1: ZZ1,ZZ2(original) =', ZZ1,ZZ2
write(*,*) 'Source BEG1: zz1,zz2(in MARS) =', zc,zc+dz
write(*,*) numsep=NSTOP/5 ! 1kW + 4kW =5kW
write(*,10) numsep
10 format('Source BEG1: injection septum =',9x,'1 ',i10)
write(*,11) numsep+1,NSTOP
11 format('Source BEG1: STRUCT source =',i10,' -',i10)
number=0
ENDIF
if (NI.gt.numsep) goto 1
**
** Injection septum source 1kW
**
pos(1)=XX
pos(2)=YY
pos(3)=zc+dz*rand() ! ---- Z sampling-----
dir(1)=0.d0
dir(2)=0.d0
dir(3)=1.d0
call flat2glob( pos, dir )
X = pos(1)
Y = pos(2)
Z = pos(3)
DCX = dir(1)
DCY = dir(2)
DCZ = dir(3)
ncount=ncount+1
if (ncount.ge.NSTOP/10) then
   write(*,*) 'septum source',NI,NSTOP
   write(61,* ) 'septum source',NI,NSTOP
   ncount=0
endif
return
**
** STRUCT source 4kW
**
1 READ(7,* ,END=2)E,pos(1),pos(2),pos(3),dir(1),dir(2),dir(3)
JJ=1 ! proton
number=number+1
x00=pos(1)
y00=pos(2)
z00=pos(3)
pos(3)=pos(3)-pos0 + tun_length
```

```

if (pos(3).gt.length) goto 1
c      -0.1 is to avoid the bend again in bending magnet
pos(3)=pos(3)-0.1d0
** coordinate system transit
** (beam-line-coordinate-system --> actual-coordinate-system)
      call flat2glob( pos, dir )
**
X = pos(1)
Y = pos(2)
Z = pos(3)
DCX = dir(1)
DCY = dir(2)
DCZ = dir(3)
nccount=nccount+1
if (nccount.ge.NSTOP/10) then
      write(*,*) 'STRUCT source',NI,NSTOP
      write(61,*).'STRUCT source',NI,NSTOP
      nccount=0
endif
RETURN
2  REWIND 7
number=0
GO TO 1
end
```

B.7.2 Source at the extraction region

1kW source at the extraction septum.

```

subroutine beg1(JJ,W,E,X,Y,Z,DCX,DCY,DCZ,TOFF,INTA,NREG1)
implicit none
integer JJ, INTA, NREG1
double precision W,E,X,Y,Z,DCX,DCY,DCZ,TOFF
integer NI,NSTOP,NUPRI,NHIPR
COMMON/HIST/NI,NSTOP,NUPRI,NHIPR

E-DEFINES EACH OR ANY OF THE 10 PARAMETERS
OF INITIAL SOURCE PARTICLES

RRANGE A POINT-LIKE INTERACTION IF INTA=1

ARTICLE TAGGING IN 'MTAGG' SOURCE ZONES OF 'ETGG' ENERGY
INTERVALS FOR 'NTAGG' DETECTOR ZONES
DEFAULTS: NUMTAG=6, MTAGG=0, INTAG=1, IETAG=4

REVISION: 09-MAR-2001

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.
.
INSERT YOUR SOURCE TERM HERE ====
SOURCE PARTICLE READING FROM STRUCT-OUTPUT =====

traction septum

double precision XX
double precision YY1,YY2
double precision ZZ
DATA XX/0.d0/
DATA YY1,YY2/9.d0, 11.d0/
DATA ZZ/12527.9d0/
double precision dy,zc,rand
double precision pos(3),dir(3),pos0,bmlparams
external bmlparams
INTEGER NENTER1
DATA NENTER1/0/
SAVE dy,zc
INTEGER ncount
DATA ncount/0/
IF (NENTER1.EQ.0) THEN
  NENTER1=1
  pos0=bmlparams( 1 )
  zc=ZZ - pos0
  dy=YY2-YY1
  write(*,*) 'Source BEG1: pos0 =', pos0
  write(*,*) 'Source BEG1: Z(original) =', ZZ
  write(*,*) 'Source BEG1: Z(in MARS) =', zc
ENDIF
x=XX
y=YY1 + dy*rand() !----- Y sampling-----
zc=z
ncount=ncount+1
if (ncount.ge.NSTOP/10) then
  write(*,*) NI,NSTOP
  write(61,*) NI,NSTOP
  ncount=0
endif
return
end

```

B.7.3 Outer layer leakage source

Generate the sources for the 2nd-, 3rd- and 4th-layer which were leaked from the previous layer boundary and were stored in the files.

```

subroutine beg1(JJ,W,E,X,Y,Z,DCX,DCY,DCZ,TOFF,INTA,NREG1)
implicit none
integer JJ, INTA, NREG1
double precision W,E,X,Y,Z,DCX,DCY,DCZ,TOFF
integer NI,NSTOP,NUPRI,NHIPR
COMMON/HIST/NI,NSTOP,NUPRI,NHIPR
C.....RE-DEFINES EACH OR ANY OF THE 10 PARAMETERS
C OF INITIAL SOURCE PARTICLES
C
C ARRANGE A POINT-LIKE INTERACTION IF INTA=1
C
C PARTICLE TAGGING IN 'MTAGG' SOURCE ZONES OF 'ETGG' ENERGY
C INTERVALS FOR 'NTAGG' DETECTOR ZONES
C DEFAULTS: NUMTAG=6, MTAGG=0, INTAG=1, IETAG=4
C
C REVISION: 09-MAR-2001
C
C.....C++ INSERT YOUR SOURCE TERM HERE +++
C== SOURCE PARTICLE READING FROM STRUCT-OUTPUT =====
C
C source for deep penetration
C leakage particle of previous calculation
C
double precision bmlparams,pos0,length,zp,zdd,tun_length
external bmlparams
DATA tun_length /34833.3d0/
INTEGER NENTER
DATA NENTER/0/
SAVE NENTER
INTEGER ncount
DATA ncount/0/
double precision wa
INTEGER ns,NSTOP_pre,i
INTEGER nn,nn1
DATA nn,nn1,ns/0,0,0/
SAVE nn,nn1,zdd,wa
IF ( NENTER .EQ. 0 ) THEN
  NENTER = 1
C ===== OPEN STRUCT-OUTPUT FILE =====NAKAO=====
OPEN (UNIT=7,FILE='LEAK.INP',STATUS='OLD')
C =====
write(*,13)
13 format('Reading Source Particles....')
read(7,'(i1)',end=10) i
ns=ns+1
goto 12
10 ns=ns-1
rewind(7)
read(7,*) NSTOP_pre
wa=DBLE(ns)/DBLE(NSTOP_pre)
write(*,11) NSTOP_pre,ns,wa
11 format('Previous calculation '
& , ' source particle  =',i10/
& , ' leakage particle =',i10/
& , ' weight correction =',1pe10.3/)
pos0=bmlparams( 1 )
length=bmlparams( 2 )
if (pos0>length .gt. tun_length ) then
  zdd=pos0-tun_length
else
  zdd=pos0
endif
OPEN (61,FILE='HISTORY')
ENDIF
1 READ(7,100,END=2)jj,x,y,zp,dcx,dcy,dcz,e,w
100 format(i1,2f10.0,f11.0,5f10.0)
z=zp-zdd ! z value
www=wa ! weight
ncount=ncount+1
if (ncount.ge.NSTOP/10) then
  write(*,*) NI,NSTOP
  write(61,*) NI,NSTOP
  ncount=0
endif
RETURN
2 rewind(7)
goto 1
end

C.....PARTICLES LEAKAGE SPECIAL SCORING
C JJ= 1 2 3 4 5 6 7 8 9 10 11 12
C P   N   PI+ PI- K- K+ MU+ MU- GAM E- E+ AP
C
C REVISION: 11-JUN-1998
C
C.....double precision W,E,X,Y,Z,DCX,DCY,DCZ,TOFF
INTEGER JJ,N_K
double precision ZMIN,ZMAX,REXT,DISMAX
double precision ZORIG,PHIT,XHIT,YHIT,ZHIT,JHIT
INTEGER NI,NSTOP,NUPRI,NHIPR
COMMON/STAZ1/ZMIN,ZMAX,REXT,DISMAX
: /HIST/NI,NSTOP,NUPRI,NHIPR
: /BLZTAG/ZORIG,PHIT,XHIT,YHIT,ZHIT,JHIT
integer number
double precision x00,y00,z00
common/nakao/x00,y00,z00,number
double precision pos(3),dir(3),pos0,length,bmlparams,zdd,zp
external bmlparams
double precision posx,PosY,Posz,Dirx,Diry,Dirz,Plane
double precision Posx0,Posy0,Posz0,Dirx0,Diry0,Dirz0,Plane0
double precision Tun_Length
DATA Tun_Length /34833.3d0/
INTEGER NENTER
DATA NENTER/0/
SAVE NENTER,Posx,PosY,Posz,Dirx,Diry,Dirz
SAVE Posx0,Posy0,Posz0,Dirx0,Diry0,Dirz0,zdd
INTEGER nn,nn0,nn1
DATA nn,nn0,nn1/0,0,0/
SAVE nn,nn0,nn1
IF ( NENTER .EQ. 0 ) THEN
  NENTER = 1
  pos=bmlparams( 1 )
  length=bmlparams( 2 )
  if (pos0>length .gt. tun_length ) then
    zdd=pos0-tun_length
  else
    zdd=pos0
  endif
  pos(1)=0.0d0
  pos(2)=0.0d0
  pos(3)=0.0d0
  dir(1)=0.0d0
  dir(2)=0.0d0
  dir(3)=-1.0d0
  call flat2glob( pos, dir )
  posx=Pos(1)
  posy=Pos(2)
  posz=Pos(3)
  dirx=Dir(1)
  diry=Dir(2)
  dirz=Dir(3)
  length=bmlparams( 2 )
  pos(1)=0.0d0
  pos(2)=0.0d0
  pos(3)=length
  dir(1)=0.0d0
  dir(2)=0.0d0
  dir(3)=1.0d0
  call flat2glob( pos, dir )
  posx=Pos(1)
  posy=Pos(2)
  posz=Pos(3)
  dirx=Dir(1)
  diry=Dir(2)
  dirz=Dir(3)
  write(56,*) NSTOP
  write(57,*) NSTOP
  write(58,*) NSTOP
  open(59,file='LEAKforward_detail')
ENDIF
** jj: 1(p), 2(n), 3(pi+), 4(pi-)
if (jj.gt.4) return
zp=z+zdd
***** backward leak *****
plane0=(x-posx)*dirx+(y-posy)*diry+(z-posz)*dirz
if (plane0.ge.0.0d0) then
  nn0=nn0+1
  write(58,102) jj,x,y,zp,dcx,dcy,dcz,e,w,nn0
  return
endif
***** forward leak *****
plane=(x-posx)*dirx+(y-posy)*diry+(z-posz)*dirz
if (plane.ge.0.0d0) then
  nn1=nn1+1
  write(57,102) jj,x,y,zp,dcx,dcy,dcz,e,w,nn1
  write(59,100) jj,x,y,zp,dcx,dcy,dcz,e,w,x00,y00,z00,number,nn1
100 format(i1,1x,1p2e10.3,1pe11.4,1x,1p3e10.3,
& 1p2e11.3,2x,1p2e10.3,1pe11.3,i6,i5)
  return
endif
***** Side leak *****
nn=nn+1
write(56,102) jj,x,y,zp,dcx,dcy,dcz,e,w,nn
102 format(i1,1p2e10.3,1pe11.4,1p5e10.3,i6)
RETURN
END

```

B.8 Leak

```

SUBROUTINE LEAK(N,K,JJ,W,E,X,Y,Z,DCX,DCY,DCZ,TOFF)
implicit none
C.....PARTICLES LEAKAGE SPECIAL SCORING
C JJ= 1 2 3 4 5 6 7 8 9 10 11 12
C P   N   PI+ PI- K- K+ MU+ MU- GAM E- E+ AP
C
C REVISION: 11-JUN-1998
C
C.....double precision W,E,X,Y,Z,DCX,DCY,DCZ,TOFF
INTEGER JJ,N_K
double precision ZMIN,ZMAX,REXT,DISMAX
double precision ZORIG,PHIT,XHIT,YHIT,ZHIT,JHIT
INTEGER NI,NSTOP,NUPRI,NHIPR
COMMON/STAZ1/ZMIN,ZMAX,REXT,DISMAX
: /HIST/NI,NSTOP,NUPRI,NHIPR
: /BLZTAG/ZORIG,PHIT,XHIT,YHIT,ZHIT,JHIT
integer number
double precision x00,y00,z00
common/nakao/x00,y00,z00,number
double precision pos(3),dir(3),pos0,length,bmlparams,zdd,zp
external bmlparams
double precision posx,PosY,Posz,Dirx,Diry,Dirz,Plane
double precision Posx0,Posy0,Posz0,Dirx0,Diry0,Dirz0,Plane0
double precision Tun_Length
DATA Tun_Length /34833.3d0/
INTEGER NENTER
DATA NENTER/0/
SAVE NENTER,Posx,PosY,Posz,Dirx,Diry,Dirz
SAVE Posx0,Posy0,Posz0,Dirx0,Diry0,Dirz0,zdd
INTEGER nn,nn0,nn1
DATA nn,nn0,nn1/0,0,0/
SAVE nn,nn0,nn1
IF ( NENTER .EQ. 0 ) THEN
  NENTER = 1
  pos=bmlparams( 1 )
  length=bmlparams( 2 )
  if (pos0>length .gt. tun_length ) then
    zdd=pos0-tun_length
  else
    zdd=pos0
  endif
  pos(1)=0.0d0
  pos(2)=0.0d0
  pos(3)=0.0d0
  dir(1)=0.0d0
  dir(2)=0.0d0
  dir(3)=-1.0d0
  call flat2glob( pos, dir )
  posx=Pos(1)
  posy=Pos(2)
  posz=Pos(3)
  dirx=Dir(1)
  diry=Dir(2)
  dirz=Dir(3)
  length=bmlparams( 2 )
  pos(1)=0.0d0
  pos(2)=0.0d0
  pos(3)=length
  dir(1)=0.0d0
  dir(2)=0.0d0
  dir(3)=1.0d0
  call flat2glob( pos, dir )
  posx=Pos(1)
  posy=Pos(2)
  posz=Pos(3)
  dirx=Dir(1)
  diry=Dir(2)
  dirz=Dir(3)
  write(56,*) NSTOP
  write(57,*) NSTOP
  write(58,*) NSTOP
  open(59,file='LEAKforward_detail')
ENDIF
** jj: 1(p), 2(n), 3(pi+), 4(pi-)
if (jj.gt.4) return
zp=z+zdd
***** backward leak *****
plane0=(x-posx)*dirx+(y-posy)*diry+(z-posz)*dirz
if (plane0.ge.0.0d0) then
  nn0=nn0+1
  write(58,102) jj,x,y,zp,dcx,dcy,dcz,e,w,nn0
  return
endif
***** forward leak *****
plane=(x-posx)*dirx+(y-posy)*diry+(z-posz)*dirz
if (plane.ge.0.0d0) then
  nn1=nn1+1
  write(57,102) jj,x,y,zp,dcx,dcy,dcz,e,w,nn1
  write(59,100) jj,x,y,zp,dcx,dcy,dcz,e,w,x00,y00,z00,number,nn1
100 format(i1,1x,1p2e10.3,1pe11.4,1x,1p3e10.3,
& 1p2e11.3,2x,1p2e10.3,1pe11.3,i6,i5)
  return
endif
***** Side leak *****
nn=nn+1
write(56,102) jj,x,y,zp,dcx,dcy,dcz,e,w,nn
102 format(i1,1p2e10.3,1pe11.4,1p5e10.3,i6)
RETURN
END

```